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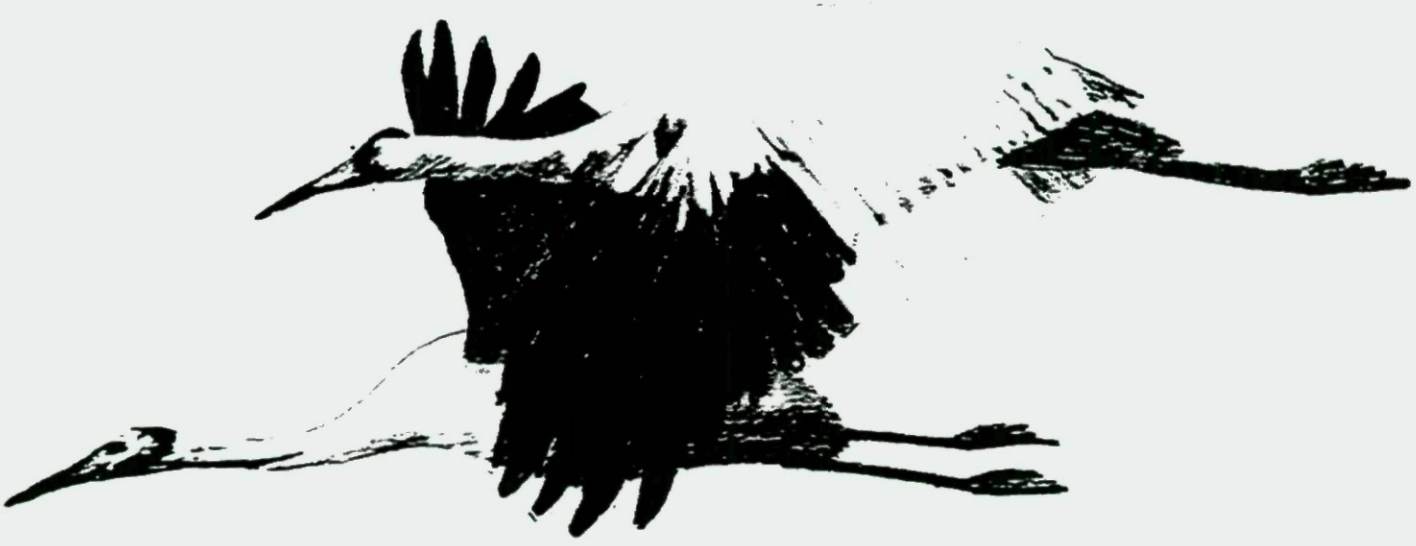
WHOOPING CRANE

RECOVERY PLAN



1994

U.S. FISH AND WILDLIFE SERVICE
REGION 2, ALBUQUERQUE, NEW MEXICO

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WHOOPING CRANE
RECOVERY PLAN

TECHNICAL/AGENCY DRAFT
(Second Revision, 1992)

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Prepared by the Whooping Crane Recovery Team

Dr. James C. Lewis, Leader
U.S. Fish and Wildlife Service - Region 2
Albuquerque, New Mexico

Dr. George Archibald
International Crane Foundation
Baraboo, Wisconsin

Dr. Rod C. Drewien
University of Idaho
Moscow, Idaho

Dr. Roger Edwards
Canadian Wildlife Service
Edmonton, Alberta

Dr. George Gee
National Biological Survey
Laurel, Maryland

Bill Huey
Whooping Crane Conservation Association
Santa Fe, New Mexico

Lee Ann Linam
Texas Parks and Wildlife Department
Austin, Texas

Ross A. Lock
Nebraska Game and Parks Commission
Lincoln, Nebraska

Steve Nesbitt
Florida Game and Fresh Water Fish Commission
Gainesville, Florida

Tom Stehn
U.S. Fish and Wildlife Service
Austwell, Texas

for

U.S. Fish and Wildlife Service
Region 2
Albuquerque, New Mexico

Approved: John G. Rogers
Regional Director, U.S. Fish and Wildlife Service

Date: 11 February 1994

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DISCLAIMER

Recovery plans delineate reasonable actions which are believed to be required to recover and/or protect listed species. Plans are published by the U.S. Fish and Wildlife Service (Service), sometimes prepared with the assistance of recovery teams, contractors, state agencies, and others. Objectives will be attained and any necessary funds made available subject to budgetary and other constraints affecting the parties involved, as well as the need to address other priorities.

Estimates of cost and task duration as listed in Part III have some uncertainty depending on the nature of the task. Duration of some research tasks are unknown because they are experimental in nature and it is difficult to predict the interval required to complete the task or to attain required data sets for statistical analysis. Costs of some management tasks are uncertain when they involve activities for which there exists no previous cost experience.

Recovery plans do not necessarily represent the views nor the official positions or approval of any individuals or agencies involved in the plan formulation, other than the Service. They represent the official position of the Service only after they have been signed by the Regional Director or Director as approved. Approved recovery plans are subject to modification as dictated by new findings, changes in species status, and the completion of *recovery tasks.*

LITERATURE CITATION

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The cover artwork showing an adult and a juvenile whooping crane in flight, is by Jerry Fuhriman, a former employee of the U.S. Fish and Wildlife Service. This second revision of the Recovery Plan has drawn significantly on material in the previous versions. For their considerable contributions to previous plans, we thank David L. Olsen, David R. Blankinship, Dr. James Carpenter, Dr. Ray C. Erickson, Dr. Harold D. Irby, Lawrence S. Smith, Conrad Fjetland, Dr. F. Graham Cooch, Dr. Scott R. Derrickson, Dr. Bruce C. Thompson, Ernie Kuyt, and Gary Halvorson.

PREFACE

The Whooping Crane Recovery Plan was prepared under the authority of the Endangered Species Act of 1973, as amended. Decision makers are provided with an orderly set of events which, if carried to successful completion, will change the status of this species from the endangered to the threatened level. The Plan compiles management and research efforts that are underway and proposes additional efforts needed to assure the recovery of the whooping crane. Funding levels and time schedules are estimated, and priorities set for each management and research effort.

This revision of the Whooping Crane Recovery Plan describes only those recovery actions and costs required for the birds and habitat within the boundaries of the United States. Recovery actions are carefully coordinated with the Canadian whooping crane recovery team. Recovery actions to be undertaken in Canada are described in the Canadian Whooping Crane Recovery Plan (Edwards et al. 1993). Cooperative recovery actions of the two nations are outlined in a "Memorandum of Understanding. . .On The Conservation Of The Whooping Crane" approved in April 1990. When the United States and Canadian recovery plans are again revised, the U.S. Whooping Crane Recovery Team has recommended that the plans be combined as a single plan.

EXECUTIVE SUMMARY

Current Species Status: This species was listed as endangered in 1970 and critical habitat was designated in 1978. Whooping cranes currently exist in three wild populations and at five captive locations. The December 1993 wild population is estimated at 160, including 141 individuals in the only self-sustaining population, 10 birds survived in the Rocky Mountain Population (one in captivity), and 10 captive-reared birds survive in Florida in an experiment to start a nonmigratory population. The captive population contained 101 birds.

Habitat Requirements and Limiting Factors: Marshes, lake, ponds, and rivers provide nesting and migration habitat for the main wild population which nests in Wood Buffalo National Park (WBNP) and adjacent areas of Canada. This population, called herein the AWP, winters in coastal marshes and estuarine habitat of Texas. Historic population declines resulted from habitat destruction, shooting, and displacement by activities of man.

Recovery Objective: Downlisting by year 2020. A delisting goal is not identified at this time. The downlisting goal is a minimum of 40 nesting pairs in the AWP and a minimum of 25 pairs occurring in self-sustaining populations at each of two other discrete locations. These breeding pair levels must be attained or exceeded for 10 years before downlisting occurs. The recovery actions may result in migratory and nonmigratory populations as occurred historically in North America.

Actions Needed:

1. Continue to build the AWP population to minimize the chance that a catastrophic event will eradicate this population. Protect and manage habitat of all wild populations.

2. Attain breeding pair and productivity goals at two captive facilities in the United States and one in Canada to produce the birds required for reintroductions. Continue research to improve production of captive flocks, to identify appropriate reintroduction sites and improve reintroduction techniques.

3. Establish two additional self-sustaining wild populations.

4. Maintain an information/education program.

Estimated Cost of Recovery for First Decade ($000's):

	Need 1	Need 2	Need 3	Need 4	Total
FY 1	1,105	840	461	20	2,421
FY 2	1,105	840	461	20	2,421
FY 3	950	840	461	20	2,266
FY 4	945	840	461	20	2,266
FY 5	935	840	461	20	2,256
FY 6	935	840	461	20	2,256
FY 7	935	740	461	20	2,156
FY 8	935	740	461	20	2,156
FY 9	935	690	461	20	2,106
FY 10	935	690	461	20	2,106

Total Cost to Downlist: $48,120

Date of Recovery: The estimated time to achieve downlisting is year 2020.

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PART I. INTRODUCTION

If one had to choose a species or subspecies currently on the United States' endangered species list to symbolize the endangered species program, the whooping crane (Grus americana) would be a prime candidate. This crane's annual travels are newsworthy and its story dramatic. It is also a symbol of international efforts to save endangered wildlife. During the last 50 years, many people have become involved in the sometimes frustrating attempts to save whooping cranes for future generations to enjoy.

Management actions in the United States and Canada have resulted in a gradual increase in their number from a low in 1941 when only 15 or 16 remained in the flock wintering in Texas. In December 1993, there were about 261 whooping cranes, including both wild and captive populations. The Endangered Species Act of 1973 (16 U.S.C., 1531-1543; 87 Stat. 884), which resulted in establishing the Whooping Crane Recovery Team and developing this Plan, facilitated further actions on behalf of the species. The whooping crane was listed as threatened with extinction in 1967 (Fed. Reg. Vol. 32, Number 48, March 11) and as endangered in 1970 (Fed. Reg. Vol. 35, Number 199, October 13). Critical habitat was designated in 1978 (Fed. Reg. Vol. 43, Number 94, May 15). Recovery is implemented cooperatively by Canada and the United States (Lewis 1991).

A. Description

The whooping crane is in the Family Gruidae, Order Gruiformes. The closest taxonomic relatives in continental North America are five races of sandhill crane (G. canadensis), the lesser (G. c. canadensis), Canadian (G. c. rowani), greater (G. c. tabida), Florida (G. c. pratensis), and Mississippi (G. c. pulla) (the last also listed as endangered). The common name "whooping crane" probably originated from the loud, single-note vocalization given repeatedly by the birds when they are alarmed.

The whooping crane is the tallest North American bird; males approach 1.5 m when standing erect, and exceed the greater sandhill crane in height by 12 to 20 cm. Males are generally larger than females. Captive males average 7.3 kg, and females 6.4 kg. Seasonal weight variation is considerable, with a maximum in December and January and a minimum in July and August. External measurements from preserved specimens have been summarized by Walkinshaw (1973:166). In appearance, whooping cranes are sexually monomorphic. However, the guard call vocalization is sexually distinct (98.8 percent accurate, Carlson 1991) and the vocalization and visual components of the unison call are sexually distinct (Archibald 1975). Vocal analysis is not sufficiently accurate (64.4 percent) to identify individual birds (Carlson 1991).

Adult plumage is snowy white except for black primaries, black or grayish alulae, sparse black bristly feathers on the carmine crown and malar region, and a dark gray-black wedge-shaped patch on the nape. The size of the post-occipital patch varies considerably between individuals. The black primaries and alulae are not visible when the wings are folded back, and the plumed, decurved tertials ordinarily conceal the short tail. The strong bill is a dark olive-gray, which becomes lighter during the breeding season. The area at the

base of the bill is pink or rosaceous, and the iris of the eye is yellow. The legs and feet are gray-black.

The juvenile plumage is a reddish cinnamon color. At age 80-100 days, the chick is capable of sustained flight. At age 120 days, white feathers begin to appear on the neck and back. Juvenile plumage is replaced through the winter months. The plumage is predominantly white by the following spring and the dark red crown, lores, and malar areas are apparent. Rusty juvenile plumage remains only on the head, the upper neck, secondary wing coverts, and scapulars (Stephenson 1971). Yearlings achieve typically adult plumage late in their second summer.

B. Distribution

Historical Distribution: Fossilized remains from the Upper Pliocene in Idaho (Miller 1944, Feduccia 1967), and from the Pleistocene in California, Kansas, and Florida (Wetmore 1931, 1956) appear inseparable from the present form. Current evidence indicates that the historical range extended from the Arctic coast south to central Mexico, and from Utah east to New Jersey, South Carolina, Georgia, and Florida (Allen 1952, Nesbitt 1982). Distribution of these fossil remains suggests a wider distribution during the Pleistocene.

Allen (1952:83) estimated that the whooping crane population in "...1860, or possibly 1870, totalled between 1300 and 1400 individuals." Banks (1978), using two independent techniques, derived estimates of 500 to 700 whooping cranes present in 1870 (Banks, R.C. 1978. The size of the early whooping crane populations. Unpublished report. U.S. Fish and Wildlife Service files. 10 pp.). Regardless of the precise number, the whooping crane was uncommon, and its numbers rapidly declined by the late 19th century. By 1937, only two small breeding populations remained--a nonmigratory population which inhabited the area around White Lake in southwestern Louisiana, and a migratory population, hereafter called the Aransas/Wood Buffalo Population (AWP), which wintered on the Aransas National Wildlife Refuge (NWR) in coastal Texas and nested in an unknown location. The remnant Louisiana population was reduced from 13 to 6 birds following a hurricane in August 1940, and the last individual was taken into captivity in March 1950.

The AWP was counted each winter in Texas after the Aransas NWR was established in 1937 (Table 1). Limitations on the use of aircraft during World War II made census difficult, but the only obvious disparity occurred in the winter of 1945-46, when the survey count was four birds less than the number of white-plumaged birds returning the following fall.

The principal breeding range in the mid 1800's extended from central Illinois northwestward through northern Iowa, western Minnesota, northeastern North Dakota, southern Manitoba, and Saskatchewan, to the general vicinity of Edmonton, Alberta (Fig. 1). Some nesting apparently occurred at other sites such as Wyoming in the 1900's, but documentation is limited (Allen 1952, Kemsies 1930). The whooping crane disappeared from the heart of its breeding range in the north-central United States by the 1890's. The last documented nesting in the aspen parklands of Canada occurred at Eagle Lake (now called Kiyiu Lake),

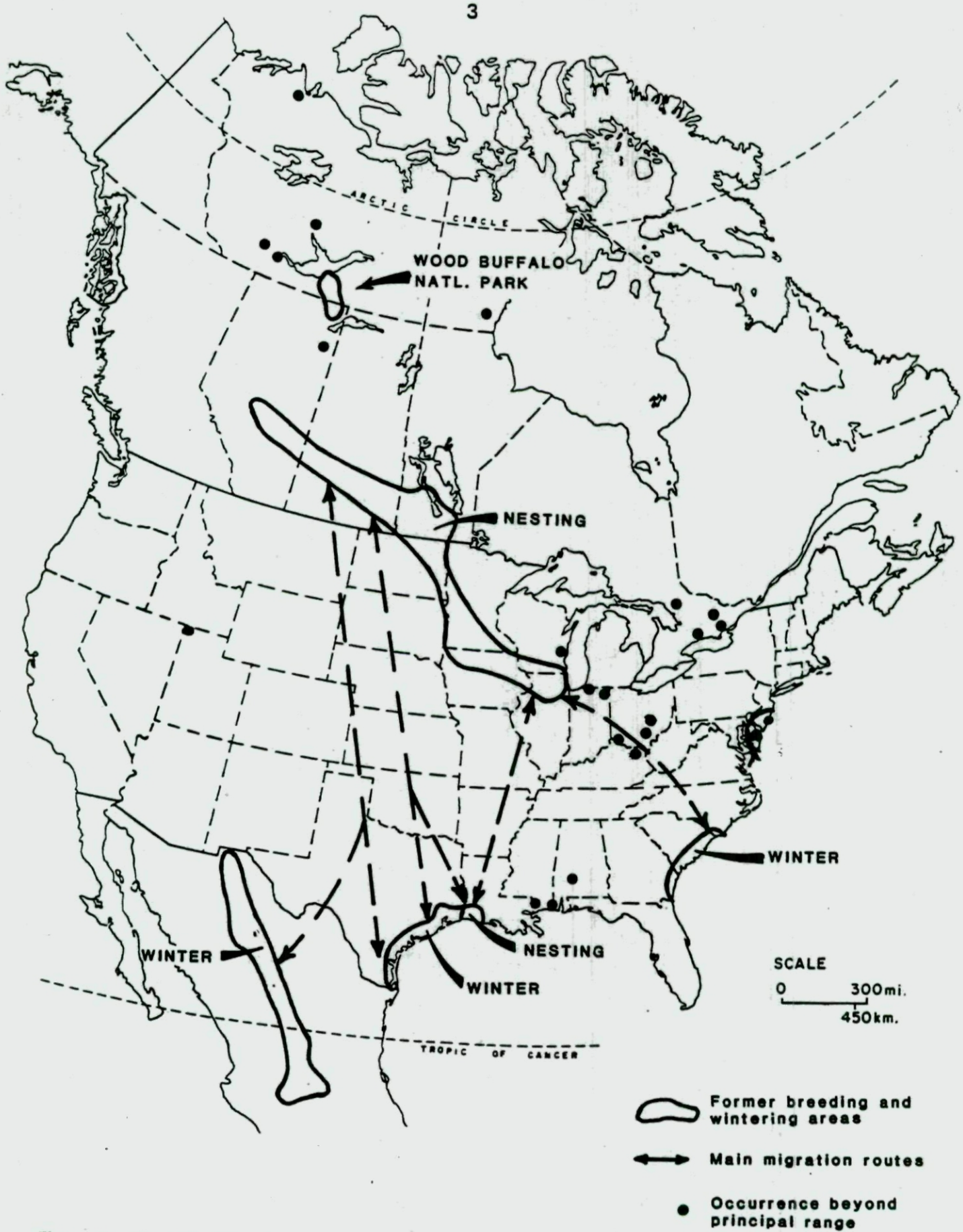

Figure 1. The principal known breeding and wintering areas of the whooping cranes (Grus americana) in "recent times" (adapted from Allen 1952).

Table 1. Whooping crane peak winter populations of the AWP and other populations, 1938-1993a.

Winter	AWP Adult	AWP Young	AWP Subtotal	Other Populations	Total
1938-39	14	4	18	11	29
1939-40	15	7	22	13	35
1940-41	21	5	26	6	32
1941-42a	14(13)	2	16(15)	6	22
1942-43	15	4	19	5	24
1943-44	16	5	21	4	25
1944-45	15	3	18	3	21
1945-46	18(14)	4(3)	22(17)	2	24
1946-47	22	3	25	2	27
1947-48	25	6	31	1	32
1948-49	27	3	30	1	31
1949-50	30	4	34	1	35
1950-51	26	5	31		31
1951-52	20	5	25		25
1952-53	19	2	21		21
1953-54	21	3	24		24
1954-55	21	0	21		21
1955-56	20	8	28		28
1956-57	22	2	24		24
1957-58	22	4	26		26
1958-59	23	9	32		32
1959-60	31	2	33		33
1960-61	30	6	36		36
1961-62	34	5	39		39
1962-63	32	0	32		32
1963-64	26(28)	7	33(35)		33
1964-65	32	10	42		42
1965-66	36	8	44		44
1966-67	38	5	43		43
1967-68	39	9	48		48
1968-69	44	6	50		50
1969-70	48	8	56		56
1970-71	51	6	57		57
1971-72	54	5	59		59
1972-73	46	5	51		51
1973-74	47	2	49	RMP	49
1974-75	47	2	49	Adult Young	49
1975-76	49	8	57	4	61

Table 1. (continued)

Winter	AWP Adult	AWP Young	AWP Subtotal	Other Populations		Total
1976-77	57	12	69	3	3	75
1977-78	62	10	72	6	2	80
1978-79	68	7	75	6	3	84
1979-80	70	6	76	8	7	91
1980-81	72	6	78	15	5	98
1981-82	71	2	73	13	0	86
1982-83	67	6	73	10	4	87
1983-84	68	7	75	13	17	105
1984-85	71	15	86	21	12	119
1985-86	81	16	97	27	4	128
1986-87	89	21	110	20	1	131
1987-88	109	25	134	16	0	150
1988-89	119	19	138	14	0	152
1989-90	126	20	146	13	0	159
1990-91	133	13	146	13	0	159
1991-92	124	8	132	12	0	144
1992-93	121	15	136	9	0	145
1993-94	127	16	143	8	1	152

a Other populations column lists the Louisiana nonmigratory population 1938-1949, and Rocky Mountain Population (RMP) 1975 to 1993. Where two numbers occur in a column, the one in parenthesis is the original count and the second is the adjusted number as explained in Boyce (1987). The 1945 count at Aransas NWR and vicinity was 14 and 3, but 22 adult-plumaged birds returned to the refuge in the winter of 1946. Consequently, it is evident that some birds were not counted in 1945.

Saskatchewan, in 1922 (Hjertaas 1989), and the last reported reproduction in the nonmigratory Louisiana population occurred in 1939 (Lynch 1956, Gomez 1992). The nesting area of AWP was discovered in 1954 in WBNP, Northwest Territories, Canada (Figure 1), and this population is the only historical one that survives.

In the 19th century, there were several migration routes. The two most important ones (Allen 1952:103) were ". . .those between Louisiana and the nesting grounds in Illinois, Iowa, Minnesota, North Dakota, Manitoba, and the other from Texas and the Rio Grande Delta region of Mexico to nesting grounds in North Dakota, the Canadian Provinces, and Northwest Territories." A route through west Texas into Mexico apparently followed the route still used by sandhill cranes, and it is believed the whooping cranes regularly travelled with them to wintering areas in the central interior highlands region (Allen 1952).

Another migration route crossed the Appalachians to the Atlantic Coast. These birds apparently nested in the Hudson Bay area of Canada. Coastal areas of New Jersey, South Carolina, and river deltas farther south were the wintering grounds. The specimen records or sighting reports for some eastern locations are Alabama 1899; Arkansas 1889; Florida 1927 or 1928; Georgia 1885; Illinois 1891; Indiana 1881; Kentucky 1886; Manitoba 1948; Michigan 1882; Minnesota 1917; Mississippi 1902; Missouri 1884; New Jersey 1857; Ohio 1902; Ontario 1895; South Carolina 1850; and Wisconsin 1878 (Allen 1952, Burleigh 1944, Hallman 1965, Sprunt and Chamberlain 1949).

Atlantic Coast locations used by whooping cranes include the Cape May area and Beesley's Point at Great Egg Bay in New Jersey; the Waccamaw River in South Carolina; the deltas of the Savannah and Altamaha Rivers, and St. Simon's Island in Georgia; and the St. Augustine area of Florida. Gulf Coast locations include Mobile Bay, Alabama; Bay St. Louis in Mississippi; and the numerous records from southwestern Louisiana where the last bird was captured in 1950. Coastal Louisiana contained both a nonmigratory flock and wintering migrants (Allen 1952).

"There is evidence to suggest that whooping cranes occurred in Florida, perhaps well into the 20th century." (Nesbitt 1982:151). Nesbitt described various sightings, including one by O. E. Baynard, a respected field naturalist, who stated that the last flock of whooping cranes (14 birds) he saw in Florida was in 1911 near Micanopy, southern Alachua County. Two whooping cranes were reported east of the Kissimmee River on January 19, 1936, and a whooping crane was shot and photographed north of St. Augustine, St. Johns County, in 1927 or 1928 (Nesbitt 1982).

Records from interior areas of the southeast include the Montgomery, Alabama, area; in Arkansas at Crocketts Bluff on the White River, and near Corning; in Missouri in Jackson County near Kansas City, near Corning, in Lawrence County southwest of Springfield, in Audrain County, and near St. Louis; and in Kentucky near Louisville and Hickman. It is unknown whether these records represent wintering locations, remnants of a nonmigratory population, or wandering birds.

Today most whooping cranes migrate from WBNP in Canada to Aransas NWR on the Texas coast. This route passes south-south eastward through northeastern Alberta, southcentral Saskatchewan, northeastern Montana, western North Dakota, western South Dakota, central Nebraska and Kansas, west-central Oklahoma, and east-central Texas (Fig. 2). Scattered occurrences have, however, been reported in adjacent states and provinces.

Allen (1952) believed the tall grass prairies of southwestern Louisiana were the whooping crane's principal historical wintering range. Such prairies also occurred along the Gulf Coast of Texas and northeastern Mexico, primarily in the vicinity of the Rio Grande Delta. Other significant wintering areas were the interior tablelands in western Texas and the high plateaus of central Mexico, where whooping cranes occurred among thousands of sandhill cranes.

Present Distribution: Whooping cranes currently exist in three wild populations and at five captive locations. The only self-sustaining wild population, the AWP, nests in the Northwest Territories and adjacent areas of Alberta, Canada, primarily within the boundaries

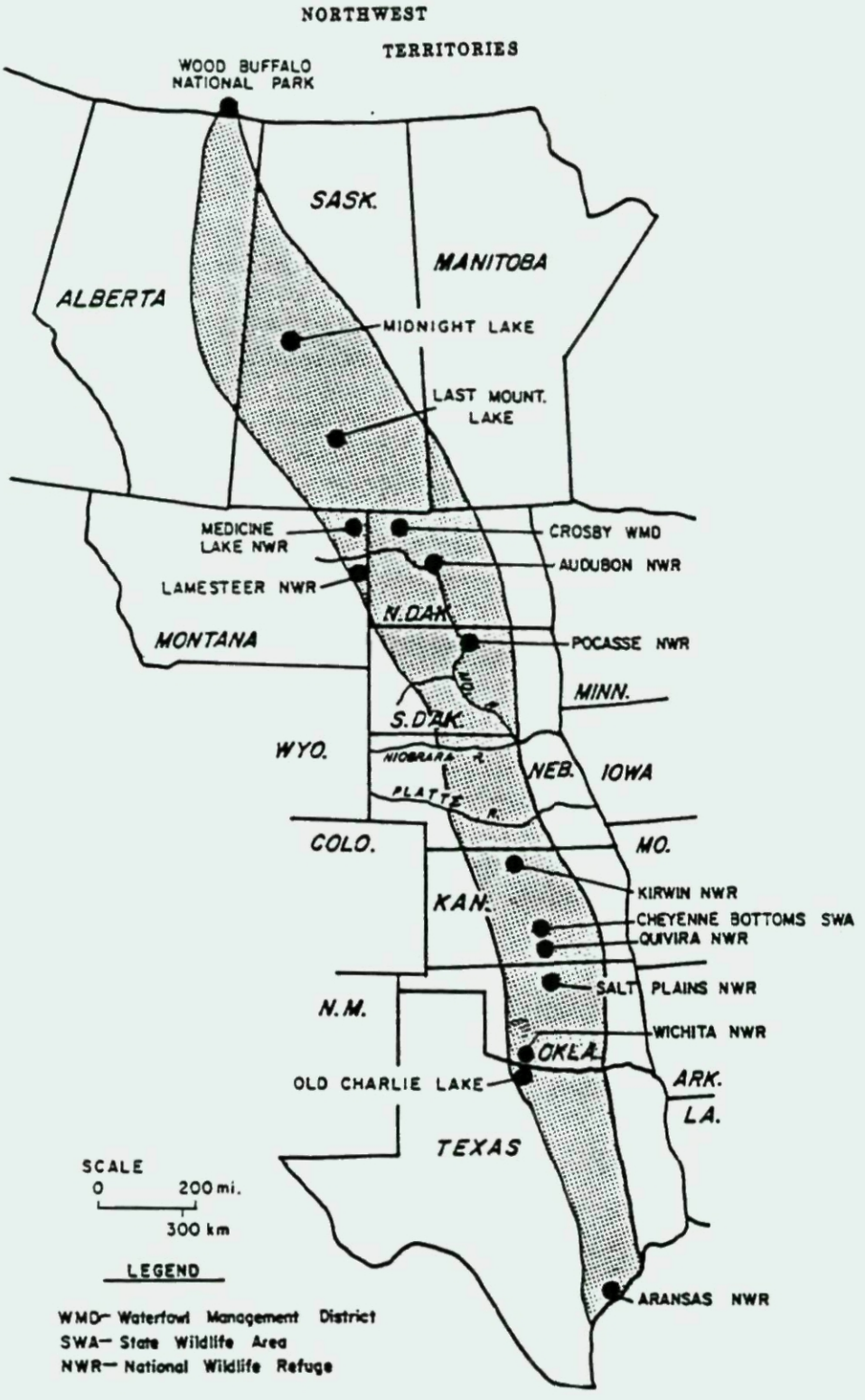

Figure 2. Breeding and wintering areas, and migration pathway of the AWP.

of WBNP. These birds winter along the Gulf of Mexico coast at Aransas NWR and adjacent areas (Fig. 2). The winter habitat extends 48-56 km along the coast from San Jose Island and Lamar Peninsula on the south to Welder Point and the central portion of Matagorda Island on the north, and consists of estuarine marshes, shallow bays, and tidal flats (Allen 1952, Blankinship 1976) (Fig. 3). Some individuals also occur occasionally on nearby rangelands or farmlands. Forty-five AWP pairs nested in 1993. The December 1993 population was 141 birds.

Another wild flock consists of eight individuals reared by wild sandhill cranes (termed cross-fostered because they were reared by another species) in an effort to establish a migratory, Rocky Mountains Population (RMP) and one captive-reared bird released in a recent experiment. The project began in 1975 with the transfer of wild whooping crane eggs from nests in WBNP to the nests of greater sandhill cranes (G. c. tabida) at Grays Lake NWR in southeastern Idaho. The sandhill cranes became the foster parents to the whooping crane chicks and taught them the migration route which the parents traditionally followed. The RMP birds spend the summer in Idaho, western Wyoming, and southwestern Montana and winter in the middle Rio Grande Valley of New Mexico.

The third wild population consists of ten birds remaining from 19 captive-reared whooping cranes released in the Kissimmee Prairie of Florida in February and December of 1993. This flock has been designated experimental nonessential and is the first step in an effort to establish a nonmigratory population in Florida. This population is hereafter called the Florida population (FP).

In May 1993, whooping cranes were located at five captive sites. Two captive flocks are maintained by the U.S. Fish and Wildlife Service, one at Patuxent Wildlife Research Center (PWRC) containing 55 birds and one at International Crane Foundation (ICF) containing 26 birds in December 1993. The Canadian Wildlife Service is starting a population at the Calgary Zoo which now contains 16 birds. Three birds reside at San Antonio Zoological Gardens and a single bird is in captivity at the Rio Grande Zoological Park in Albuquerque, New Mexico, being treated for avian tuberculosis.

In the 1970's and early 1980's, the AWP was increasing at an annual rate of 4 percent, double the rate observed prior to the mid 1950's (Binkley and Miller 1983). Subsequent population studies indicate a 10-year cycle of unknown cause in survivorship (Boyce and Miller 1985, Boyce 1987, Nedelman et al. 1987).

C. Habitat

The current nesting area within WBNP lies between the headwaters of the Nyarling, Sass, Klewi, and Little Buffalo rivers. The area is poorly drained and interspersed with numerous potholes. Wetlands vary considerably in size, shape and depth, and most possess soft marl bottoms. Wetlands are separated by narrow ridges which support an overstory of white spruce (Picea glauca), black spruce (P. mariana), tamarack (Larix laricina), and willows (Salix spp.), and an understory of dwarf birch (Betula glandulosa), Labrador tea (Ledum groenlandicum), and bearberry (Arctostaphylos uva-ursi). Bulrush (Scirpus validus) is the dominant emergent in the potholes used for nesting, although cattail (Typha sp.), sedge

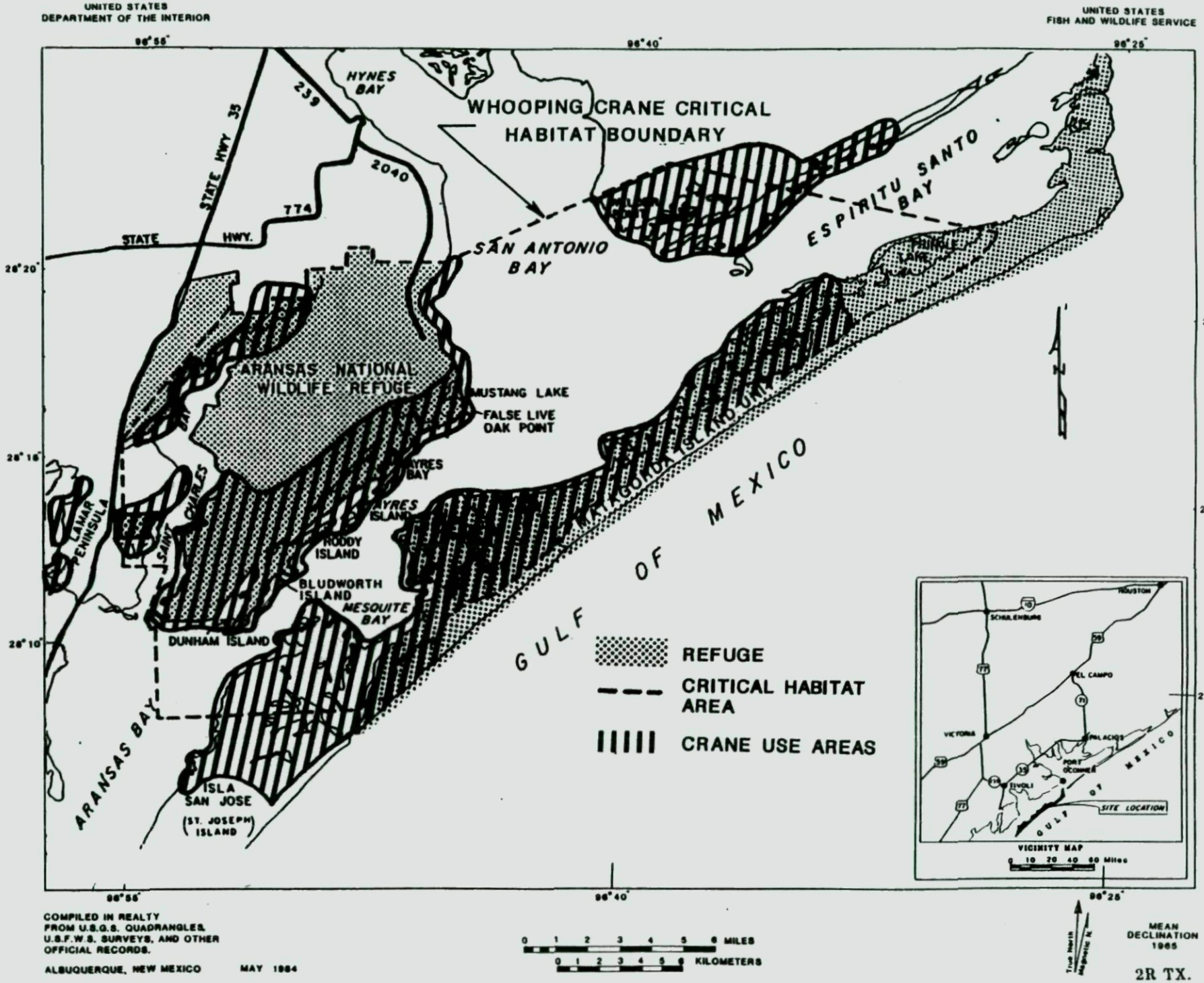

Figure 3. Wintering area, Aransas National Wildlife Refuge, and Critical Habitat boundary of the AWP on the Gulf of Mexico coast of Texas.

(Carex aquatilis), musk-grass (Chara sp.), and other aquatic plants are common (Allen 1956, Novakowski 1965, 1966, Kuyt 1976a, 1976b, 1981a).

Nest sites are being located in the rushes or sedges of marshes, sloughs, or along lake margins (Bent 1926). Allen (1956) found an abundance of invertebrates, primarily mollusks, crustaceans, and aquatic insects, in the ponds occupied by nesting pairs. He also encountered several species of minnows, frogs, and garter snakes (Thamnophis sp.), and believed that mollusks and frogs must be important items in the diet of breeding adults and their offspring.

Lightning-caused fires have burned large portions of the nesting area during drought (e.g., 1981), but losses of eggs, chicks, or adults have not been confirmed. Molting adults or flightless young would be vulnerable to fire. Wildfire may be beneficial to cranes due to removal of dense or tall vegetation thus making the area more accessible for whooping crane use and recycling nutrients.

Although the quality of the nesting habitat can be debated, there is no evidence that growth of the AWP is limited by habitat. Hatching success is high in most years (Kuyt 1976c, 1981a, 1981b) and the area is remote from human activities. Thousands of hectares of unoccupied, apparently similar habitat are available in the area. Some new pairs pioneer unoccupied nesting habitat as the population increases (Kuyt 1978b). A project of Parks Canada is underway to identify the suitable unoccupied nesting habitat within WBNP.

Whooping cranes use a variety of habitats during migration (Howe 1987, 1989, Lingle 1987, Lingle et al. 1991). Twenty-seven cranes were monitored for one or more seasons, including nine radio-marked birds and others that associated with them (Howe 1987, 1989). They fed primarily in a variety of croplands and roosted in palustrine (marshy) wetlands. A majority of the roosting wetlands were less than 4 ha (75 percent) and within 1 km of a suitable feeding site. More than 40 percent of the roosting wetlands were smaller than 0.5 ha. Although heavily vegetated wetlands were generally not used, family groups appeared to select more heavily vegetated wetlands than non-families (Howe 1987, 1989). Cropland accounted for 70 percent of the feeding sites of non-families, but wetlands accounted for 67 percent of the feeding sites of families.

Whooping cranes also roost in riverine habitat, most notably the Platte River, Middle Loup River, and Niobrara River in Nebraska; Cimarron River in Oklahoma; and the Red River in Texas (U.S. Fish and Wildlife Service confirmed sighting records). Cranes roost on submerged sandbars in wide unobstructed channels that are isolated from human disturbance (Armbruster 1990). Large palustrine wetlands are used for roosting and feeding during migration. Included in this category are those at Quivira NWR in Kansas (68 confirmed sightings), Salt Plains NWR in Oklahoma (61 sightings confirmed), Cheyenne Bottoms State Wildlife Area (34 sightings confirmed), and large reservoir margins in the Dakotas.

About 9,000 ha of salt flats on Aransas NWR and adjacent islands comprise the principal wintering grounds (Fig. 3). Marshes are dominated by salt grass (Distichlis spicata), saltwort (Batis maritima), smooth cordgrass (Spartina alterniflora), glasswort (Salicornia sp.), and sea ox-eye (Borrichia frutescens). Inland margins of the flats are dominated by Gulf cordgrass (Spartina spartinae). Interior portions of the refuge are gently rolling and sandy

and are characterized by oak brush, grassland, swales, and ponds. Typical plants include live oak (Quercus virginiana), redbay (Persea borbonia), and bluestem (Andropogon spp.) (Stevenson and Griffith 1946, Allen 1952, Labuda and Butts 1979). During the last 20 years, many upland sites have been grazed, mowed, and control burned (Labuda and Butts 1979). The refuge maintains as many as 3300 ha of grassland for cranes, waterfowl, and other wildlife. Human visitation is carefully controlled, and other potentially conflicting uses of the refuge, such as activities associated with oil and gas exploration and pumping operations, are reduced when whooping cranes are present.

As noted previously, critical habitat was designated for whooping cranes in 1978. Critical habitat is defined within the Endangered Species Act as habitat which contains those physical or biological features, essential to the conservation of the species, which may require special management considerations or protection. Critical habitat was identified for nine sites in six states (Fed. Reg. Vol. 43, Number 94, May 15). The interested reader is referred to the Federal Register for a detailed description of the sites. However, these sites are: (1) Monte Vista NWR, Colorado; (2) Alamosa NWR, Colorado; (3) Grays Lake NWR and vicinity, Idaho; (4) Cheyenne Bottoms State Waterfowl Management Area, Kansas; (6) the Platte River bottoms between Lexington and Dehman, Nebraska; (7) Bosque del Apache NWR, New Mexico; (8) Salt Plains NWR, Oklahoma; and (9) Aransas NWR and vicinity, Texas.

D. Life History

Wild whooping cranes were not individually marked until 1975 (Drewien and Bizeau 1978, Kuyt 1978a, 1979a); consequently, some aspects of their life history and population biology remain uncertain. Current estimates suggest a maximum longevity in the wild of 22-24 years (Binkley and Miller 1980). Captive individuals live 35-40 years (McNulty 1966, Moody 1931). "Crip" was at least 33 years old when he died at San Antonio Zoo in 1979. "Josephine" was at least 27 years old at the time of her death (McNulty 1966). "Can-US", a 29-year-old male, is still reproductively active in the captive flock at PWRC in 1993.

Whooping cranes are monogamous, but will remate, sometimes within only a few weeks, following the death of their mate (Blankinship 1976, Stehn 1992). Bishop and Blankinship (1982) documented several instances in which 2- and 3-year-old color-banded birds paired with unmarked birds. Kuyt (1981a) observed two instances in which nesting pairs contained one member (a male in each instance) that was known to be 3-years-old. A 3-year-old female has also nested, but pair formation can be a lengthy process. Bishop (1984) observed pair bonds that developed over 1 to 3 winters from associations in subadult flocks on the wintering grounds. The average age of first egg production is slightly over 4 years (E. Kuyt, pers. comm. 1991).

Most pairs return to the nesting area in WBNP in late April, and begin nest construction and egg laying. Experienced pairs arrive first, show considerable fidelity to their breeding territories, and normally nest in the same general vicinity each year. These nesting territories--termed "composite nesting areas"--vary considerably in size, and range from about 1.3 to 47.1 km2 (Kuyt 1976a, 1976b, 1981a). From the initiation of laying until chicks are a few weeks of age, the activities of pairs and family groups are restricted to the

breeding territory. To date, the minimum distance recorded between nests has been 600m (Kuyt pers. comm., 1991).

Eggs are normally laid in late April to mid May, and hatching occurs about 1 month later. The incubation period is from 29 to 31 days. Kuyt (1981b:126) reported that "Among 203 clutches observed between 1966 and 1980, 184 (90.6 percent) contained 2 eggs, 16 (7.9 percent) only 1 egg, and 3 (1.5 percent) 3 eggs." Eggs are light-brown or olive-buff overlaid with dark, purplish-brown blotches concentrated primarily at the blunt end. Eggs average 100 mm in length and 63 mm in width (Bent 1926, Allen 1952, Stephenson and Smart 1972). Whooping cranes may renest if their first clutch is destroyed or lost before mid-incubation (Erickson and Derrickson 1981, Derrickson and Carpenter 1981, Kuyt 1981b). Whooping cranes generally nest annually, but occasional pairs skip a nesting season for no apparent reason. When nesting habitat conditions are unsuitable, some pairs do not attempt to nest.

Whooping crane egg and tissue specimens examined for pesticide residues at Patuxent Wildlife Research Center have shown concentrations well below those encountered in most other migratory birds (Robinson et al. 1965, Lamont and Reichel 1970, Anderson and Kreitzer 1971, Lewis et al. 1992). To date there is no evidence that pesticide contamination has affected the welfare of whooping cranes.

Except for brief intervals, one member of the pair remains on the nest at all times. Parents share incubation and brood-rearing duties. Females tend to incubate at night (Allen 1952, Walkinshaw 1965, 1973) and take the primary role in feeding and caring for the young (Blankinship 1976). Parents and young return to the nest each night during the first 3-4 days after hatching. After that time, the young are brooded by their parents wherever they are when night or foul weather overtakes them. During the first 20 days after hatching, families generally remain within 1.8 km of the nest site (Kuyt pers. comm.).

Whooping cranes are omnivorous (Walkinshaw 1973), probing the soil subsurface with their bills and taking foods from the soil surface or vegetation. Young chicks are fed by their parents and gradually become more independent in their feeding until they separate from the parents preceding the next breeding season. Summer foods include large nymphal or larval forms of insects, frogs, rodents, small birds, minnows, and berries (Allen 1956, Novakowski 1966). Foods utilized during migration are poorly documented but include frogs, fish, plant tubers, crayfish, insects, and waste grains in harvested fields.

Autumn migration normally begins in mid-September, with most birds arriving on the wintering grounds between late-October and mid-November. Occasionally, stragglers may not arrive until late-December. Nonbreeders and unsuccessful breeders probably initiate and complete fall migration sooner than family groups because young-of-the-year are rarely observed among the first birds arriving in southern Saskatchewan or Texas (Allen 1952, Archibald et al. 1976, Stephen 1979).

Whooping cranes are less gregarious than sandhill cranes, and normally migrate as a single, pair, family group, or in small flocks, sometimes in the company of sandhill cranes. Flocks of up to 10 subadult whooping cranes have been seen feeding in traditional migration stopovers (staging areas) in Saskatchewan during radio tracking studies (Kuyt 1992). They

are diurnal migrants and make regular stops to feed and rest. Although whooping cranes will use a variety of habitats for foraging and roosting during these stopovers (Armbruster 1990, Lingle et al. 1991), they seem to prefer isolated sites away from human activities. This preference and the birds' rarity, result in few authenticated sightings during migration each year.

For almost half of the year, whooping cranes occupy winter quarters on and adjacent to Aransas NWR. Although close association with other whooping cranes is tolerated at times on the wintering grounds, pairs and family groups typically occupy and defend relatively discrete territories. Recent studies indicate a declining territory size as the population increases. The recent average is 117 ha (Stehn and Johnson 1987). Subadult and unpaired-adult whooping cranes form small flocks and use areas outside occupied territories (Blankinship 1976, Bishop and Blankinship 1982). Subadults tend to winter near the territories where they spent their first year (Bishop 1984). Paired cranes will often locate their first winter territory near the winter territory of one of their parents (Bishop 1984, Stehn and Johnson 1987).

Animal foods--especially blue crabs (Callinectes sapidus), clams (Tagelus plebius, Ensis minor, Rangia cuneata, Cyrtopleura costada, Phacoides pectinata, Macoma constricta), and the plant wolfberry (Lycium carolinianum) predominate in the winter diet (Allen 1952, 1956, Uhler and Locke 1970, Blankinship 1976). Most foraging occurs in the brackish bays, marshes, and salt flats lying between the mainland and barrier islands. Occasionally, they fly to upland sites when attracted by foods such as acorns (Quercus virginiana), snails, crayfish and insects, and then return to the marshes to roost. Uplands are particularly attractive when partially flooded by rainfall, burned to reduce plant cover or when food is less available in the salt flats and marshes (Bishop and Blankinship 1982). Some whooping cranes use upland sites frequently in most years but agricultural croplands adjacent to the Aransas NWR are rarely visited.

High fall tides and heavy rains sometimes flood tidal flats. In these circumstances, the birds forage almost exclusively on blue crabs and wolfberry in flooded areas. In December and January, tidal flats typically drain as a result of lower tides, and the birds move into shallow bays and channels to forage primarily on clams, although blue crabs are occasionally captured while probing the bottom. Clams are a significant dietary item when water depths are low, temperatures cold, and during drought when high salinity reduces the blue crab population. Most clams and small blue crabs (5 cm or less in width) are swallowed whole. Larger crabs are pecked into pieces before being swallowed (Blankinship 1976).

As spring approaches, dancing, unison calling (Archibald 1976), and flying increase in frequency, and are especially indicative of pre-migratory restlessness (Allen 1952, Blankinship 1976). Family groups and pairs are usually among the first to depart wintering grounds, assisted by strong southeast winds which typically occur at this time of year. First departure dates normally occur between March 25 and April 15, with the last birds usually leaving by May 1. Occasional stragglers may, however, linger into mid-May, and in 16 years in the period 1938-1992, one to 4 birds (27 birds total) have remained at Aransas NWR throughout the summer. Some of these birds were ill or crippled or mates of birds which were crippled.

Parents separate from their young of the previous year upon departure from Aransas NWR in northward migration, while en route to the breeding grounds or soon after arrival on the breeding grounds (Allen 1952, Archibald et al. 1976, Stehn unpubl. 1992, Kuyt unpubl.). Information on marked individuals suggests that most juveniles and subadults spend the summer near their natal area (Kuyt 1979b, 1981a).

E. Reasons for Listing

The impact of human settlement upon the wildlife of interior North America is dramatically evident in the changing status of the whooping crane. Cranes disappeared as agriculture claimed the northern Great Plains of the U.S. and Canada (Allen 1952). Only one small population survived. Ironically, the traditions which appear to have saved the whooping crane as a small relict breeding population in WBNP, prevent its voluntary return to what was once its principal nesting range. Re-colonization of these former breeding areas remains unlikely unless man assists with purposeful reintroduction.

Biological Characteristics: Delayed sexual maturity, small clutch size, and low recruitment rate preclude rapid population recovery. The current northern breeding grounds may be another handicap to productivity because the ice-free season is only 4 months. During that time, pairs must incubate their eggs for 29-31 days, and rear their chicks to flight age in 3 months. Consequently, unless nest loss occurs early in incubation, there is rarely time to lay a second clutch and fledge young if the first clutch fails. During 1939-1964 when there was no human interference in the form of egg removal, 180 breeding pairs produced 15 sets of siblings or one of each 12 families arriving on the Texas coast in fall contained 2 juveniles (pers. comm. E. Kuyt 1993).

During years when whooping cranes were surveyed on the breeding grounds (when no eggs have been removed), about one out of every four hatched chicks survived to reach the Texas coast. Factors which limit chick survival remain open to conjecture. Most mortality occurs soon after hatching, and chicks that fledge have a high probability of successfully completing their first migration (Kuyt 1976a). Most immediate post-hatching mortality may be related to sibling aggression and short-term food shortage because eggs hatch asynchronously and the precocial young are extremely aggressive toward each other. The dominant chick apparently obtains principal access to food made available by the parents, consequently brood-size is rapidly reduced during periods of food shortage (Miller 1973, Drewien 1973). Prolonged food shortage, possibly related to drought, and drought-increased predation (Kuyt 1981b) may account for additional mortality. Suitable nesting habitat conditions are the chief reasons for population increases 1984 through 1990.

Little is known about the importance of diseases or parasites as mortality factors. At the time of his capture (mid-September) in WBNP, due to a wing injury (Novakowski 1965), "CAN-US" was found to be infected with coccidia. Coccidia have been found in whooping crane droppings collected on the wintering grounds (Forrester et al. 1978), and have caused deaths of several whooping crane chicks at Patuxent Wildlife Research Center (Carpenter et al. 1980). Fecal accumulations and concentrations of coccidia oocysts at brooding sites on the breeding grounds may infect preflight birds. Chicks may be especially vulnerable to attack by coccidia due to the absence of acquired immunity. However, droppings normally

fall in the water, brooding sites are used only once, and it is unlikely that oocysts accumulate in the wild. Also, the defense of large territories and small brood size ensure low density use of the natal area, and thereby reduce the likelihood of coccidia oocysts being ingested in quantity sufficient to cause disease. However, infected parents can shed oocysts for most of their life and are a constant source of infection.

Although wild whooping cranes are presumably susceptible to a variety of avian diseases, evidence of disease-related mortality is only infrequently documented. However, seven wild whooping cranes have had avian tuberculosis, a subadult crane captured in New Mexico was suffering from avian cholera (Snyder et al. 1987), and one died from lead poisoning (Snyder et al. 1993). The high incidence of avian tuberculosis indicates that whooping cranes may be particularly susceptible to this disease.

Flooding of nests is thought to be rare. Drought is a far greater hazard because the attractiveness of traditional nest sites would be reduced, food supplies would be diminished, and newly-hatched chicks would be forced to travel long distances between wetlands. Drought conditions increase exposure of eggs and chicks to terrestrial predators whose movements are enhanced. Potential predators in the nesting ground include the black bear (Ursus americanus), wolverine (Gulo luscus), gray wolf (Canis lupus), red fox (Vulpes fulva), lynx (Lynx canadensis), and raven (Corvus corax), although, with the exception of ravens, these species are uncommon in the nesting area during spring and summer. A number of nests have been destroyed by black bears or other mammals, and prefledged chicks have been killed by wolves (Kuyt 1981a, 1981b); however, the overall impact of predation on recruitment remains uncertain.

Whooping cranes are exposed to various natural obstacles and problems during migration. Snow and hail storms, low temperatures, and drought can present navigational handicaps or reduce food availability. Thus, migrating cranes are exposed to a variety of hazards such as collision with obstructions, predators, disease, and illegal shooting.

Hurricanes and drought can create problems on the wintering grounds. Fortunately, the hurricane season usually ends by October 31, before most whooping cranes arrive. A late-season-hurricane could place cranes at risk due to high wind velocities. Drought influences availability and abundance of the natural food supply by altering salinity of tidal basins and estuaries (Blankinship 1976). Bobcats (Lynx rufus) prey on young whooping cranes in Texas and Florida.

Man-associated Mortality Factors and Disturbance: This subject is treated under three categories: human disturbance, habitat modification, and hunting and specimen collecting. The whooping crane is wary on the breeding grounds and will not remain near human activity. However, as evidenced by the egg transfer and banding programs, whoopers will tolerate human intrusion for short intervals. On the wintering grounds, whoopers will tolerate some human disturbance. This tolerance is evidenced by the little concern they show for barges that travel along the Gulf Intracoastal Waterway (GIWW). Both whooping cranes and sandhill cranes are disturbed by aircraft, particularly helicopters.

Settlement of the mid-continental and coastal prairies and mere human presence, as opposed to alteration of the habitat, may have interfered with the continued use of prairie and wetlands by breeding whooping cranes.

Man's conversion of pothole and prairie to hay and grain production made much of the original habitat unsuitable for whooping cranes. Disruptive practices included draining, fencing, sowing, and all of the human activity associated with these operations. The advent of rural electrification brought power lines, and collisions are known to have accounted for the death or serious injury of at least 19 whooping cranes since 1956.

Whooping cranes adhere to ancestral breeding areas, migration routes, and wintering grounds. There is little likelihood of pioneering new habitat, except locally. The only self-sustaining wild population remains vulnerable to destruction through a hurricane or contaminant spill, due primarily to its limited wintering distribution along the GIWW of the Texas coast. The GIWW experiences some of the heaviest barge traffic of any waterway in the world. Much of the tonnage is in petrochemical products. An accident resulting in a spill could potentially destroy whooping cranes and/or their food resources. Transport of petroleum products and other chemicals by barge along the GIWW has for many years been considered a potential danger to whooping cranes and other wildlife at Aransas NWR. During summer, 1974, 25 to 50 barrels of crude petroleum leaked from a barge. The high viscosity of the oil, and the prompt action by clean-up crews, limited the spill to an area averaging about 1.6 m wide and extending 16 km along the canal. This spill, and other more recent ones, emphasize the hazards which accompany the shipping of dangerous cargoes on the GIWW.

A consultant to the Army Corps of Engineers (Gulf Engineers and Consultants, Inc. 1992) assessed threats to the whooping crane and its habitat from spills of vessel fuels and cargoes. Each concluded that the hazard of spill exists, but the probability of their occurrence is low. Catastrophic events, such as a large spill are infrequent, and therefore, difficult to predict. There is a great potential for acceleration of traffic, and an increase in accidents as traffic increases from Mexico associated with ratification of the North American Free Trade Agreement. Thus, the probability of occurrence of the most likely spill (1 per 1,075 years) and worst case spill (1 per 7,982 years) are very likely conservative (Gulf Engineers and Consultants, Inc. 1992). The worst case spill estimated by the Environmental Protection Agency (1992) would be approximately 33,000 barrels of liquids.

The U.S. Coast Guard has the lead responsibility for spill response and containment. The U.S. Fish and Wildlife Service has response plans for the Gulf of Mexico (U.S. Fish and Wildlife Service 1979) and Aransas National Wildlife Refuge specifically (Robertson et al. 1993).

The latter Plan (Robertson et al. 1993) ". . .is inadequate in providing full protection for the whooping cranes. Such a plan is not possible since chemicals are transported right through the center of the whooping crane winter range. Spills of hazardous materials may threaten human health so that approach could only be done by personnel wearing special protective suits and breathing apparatus. Spill of gaseous materials could directly kill all whoopers downwind of the disaster. Response time at best is 1-2 hours by the refuge staff, and 3-4 hours by spill control specialists. An event occurring at night or during bad weather (the

most probable times), would slow response time further. In addition, the response of the whooping cranes to spilled materials and humans trying to haze the whoopers away from a spill is currently unknown."

Allen (1952) compiled records of whooping cranes known to have died from gunshot or other causes from colonial times to 1948. Most losses (about 66 percent) occurred during migration, especially between the 1880's and 1920's. Such large, conspicuous birds could not have remained long in early settled areas without drawing the attention of those who wished to reduce them to objects of closer inspection or meat for the table. Enactment of protective legislation coincided with a decline in human-caused mortality, but shootings still occur. The most recently documented loss associated with hunting was an adult female, mistaken for a snow goose near Aransas NWR in January 1989. An adult female was shot by a vandal in April 1991 as she migrated northward through Texas. Although examinations of retrieved carcasses have rarely revealed the presence of shotgun pellets, three lead pellets were found during the post-mortem examination of a male from the Rocky Mountain population in January 1984 (Snyder et al. 1992).

Whooping cranes of the AWP occasionally associate with sandhill cranes during migration and RMP birds frequently associate with sandhill cranes. Sandhill crane hunting seasons in the States in the migration corridor were originally seasonally timed or geographically limited to protect whooping cranes (Buller 1967, Archibald et al. 1976, Thompson and George 1987). Expansion of these seasons may have increased the risks to whooping cranes (Konrad 1987). This hazard needs to be monitored and precautions taken to avoid accidental shooting of whooping cranes. Tundra swan hunts recently initiated in the northern Great Plains (Montana, 1983; North Dakota, 1988; South Dakota, 1990), also present opportunities for misidentification of whooping cranes and accidental shooting.

Allen (1956) reported nearly 200 taxidermy mounts, study skins, and skeletons, and an undetermined number of eggs were in museums in the United States and Canada. Hahn (1963) indicated that 309 mounts and 9 skeletons existed in museums throughout the world. The lack of data associated with most of these specimens suggests that very few were deliberately taken by collectors associated with museums. Shooting represented a substantial drain on the population, particularly from 1870 to 1920. Allen (1952) recorded 254 kills. Considering the low reproductive potential of the species, and the small percentage of shot birds which are documented, the kill alone possibly exceeded annual reproduction by the early 1900's.

The slow growth of the AWP during recent decades seems to have resulted primarily from a decline in the mortality rate rather than an increase in recruitment (Miller et al. 1974). Consequently, if losses of white-plumaged birds can be prevented or reduced, population growth should be substantially accelerated. Between 1938-1986, 187 whooping cranes are known to have disappeared from the wild population. The causative factors underlying this substantial mortality remain largely unknown but it is clear that a high priority needs to be placed on identifying the sources of mortality and implementing remedial actions.

Probable cause of death has been identified for 9 whooping cranes, including 2 radio-tagged birds, which died on the wintering grounds. Losses were due to shooting (2 known and a third suspected), avian tuberculosis or a closely related disease (2), birds that arrived injured

at Aransas and were believed shot during fall migration (2), avian predation (1), and arriving at the refuge with a trauma injury following fall migration (1) (Lewis et al. 1992).

Between 1947 and 1990, 51 whooping cranes have been lost on the wintering grounds. This represents 1.8 percent of 2,823 wintering cranes. Three losses occurred among cranes summering on Aransas NWR. During these same years, birds that started migration in the spring and failed to return in the fall (i.e., April to November mortality) numbered 158. Twenty four percent of the total flock mortality occurred on the wintering grounds. Mortality during April through November is 3.1 times greater than mortality on the wintering grounds. Spring migration, summer, and fall migration are the periods which should receive emphasis to further diminish mortality of fledged birds (Lewis et al. 1992). As previously noted, the principal known cause of loss during migration is collision with utility lines. However, management actions need to be taken wherever they can effectively reduce mortality, regardless of relative rates of losses.

F. Economic Importance

There is much evidence that people value whooping cranes. Numerous books, magazine articles, television programs, and nature documentary films have been produced about this magnificent bird. Corporations have funded whooping crane research and recovery efforts and also have used whooping cranes in promoting their environmental concern. The Whooping Crane Conservation Association, a nonprofit group, was formed in 1961 to promote conservation of whooping cranes and to educate the public. Other organizations such as the National Audubon Society, have participated in whooping crane research, conservation, and education. The Platte River Whooping Crane Habitat Maintenance Trust was established in 1978 as a nonprofit conservation organization to protect and enhance habitat for migratory birds in Nebraska along the Platte and North Platte rivers, especially to protect and maintain whooping crane habitat.

Values for whooping cranes are also expressed in monetary expenditures. Each year 70,000 to 80,000 people visit Aransas NWR, most during the winter, spending significant amounts locally on lodging, gasoline, and supplies (Ellen Michaels, pers. comm.). In 1970, one tour boat, The Whooping Crane, offered weekend day-trips from Rockport, Texas, to view the cranes along the GIWW. By 1990, five boats offered this opportunity, spanning every day of the week. During 1990-91, approximately 17,000 people took these tours, paying an average of $20 per ticket, for a total seasonal expenditures of $340,000 (Ellen Michaels, pers. comm.). The city of Rockport estimates that wildlife-related activities result in annual gross economic benefits of $6 million to the local economy (Rockport Chamber of Commerce). Some of these benefits result from the nearby presence of whooping cranes.

Large numbers of sandhill cranes along migration routes and winter areas have begun to attract tourist dollars to other areas in North America. In several of these areas, one of the additional attractions for tourists is the possibility of sighting whooping cranes. Approximately 80,000 people visit the Platte River area of Nebraska each year during the peak of spring crane migrations, expending approximately $15 million (Lingle 1992). This interest has prompted the Grand Island, Nebraska, Chamber of Commerce to sponsor an annual festival, "Wings over the Platte", to further promote the avian attractions. Approximately 75,000 people annually visit Bosque del Apache NWR, New Mexico, the

majority when the whooping cranes and sandhill cranes are present (Peggy Mitchusson, pers. comm.). The refuge and Socorro Chamber of Commerce also sponsor a fall "Festival of the Cranes" to promote tourism. The presence of migrating whooping cranes has also heightened interest in the crane migration at Alamosa/Monte Vista NWR in Colorado. Approximately 10,000 people visit the refuge during the peak migration periods, many of these during the spring Monte Vista Crane Festival. This 4-day festival is estimated to generate about $10,000 per day in revenue to the local economies (Ann Morekill, pers. comm.). In Baraboo, Wisconsin, 30,000 people pay an entry fee of $3.75 to visit the International Crane Foundation each year where subadult whooping cranes are among the crane species on display.

The total value for most endangered species is intangible and difficult to quantify; however, in recent years economists have developed methods to attempt to approximate the value of nonmarket resources, such as endangered species. These methods measure: (1) the value people place on seeing an endangered species (use value); (2) the value they place on continued existence of the species for potential future observation value (option value); and (3) the value of simply knowing the species exists (existence value) (Randall and Stoll 1983). One method of estimating these values, the contingent valuation method, asks individuals to express their willingness to pay for nonmarket goods (Stoll 1983). Individuals are asked to estimate their willingness to pay for observing (use value) or preserving (option and existence value) the species.

Contingent valuation methodologies have been used to estimate the value of whooping cranes. In written surveys distributed in 1982-83 at Aransas NWR, refuge visitors indicated willingness to pay an average of $4.47 for an annual permit to visit the refuge and an average of $16.33 per year to support a private foundation which would be responsible for conservation of whooping cranes. A mail survey to four metropolitan areas outside of Texas indicated that respondents were willing to contribute an average of $7.13 per year to the same hypothetical foundation. Allowing for sampling error and non-response bias, the total value of the whooping crane to United States' residents appears to range between one half billion to one and one half billion dollars per year (Stoll and Johnson 1984).

Three conclusions can be drawn from this evidence of the economic value of whooping cranes. First, local economies can realize significant economic benefit from the presence of an endangered species; these localities need assistance in identifying and capturing these economic benefits. Second, values for endangered species appear to be directly associated with the public's knowledge and awareness of the species. Value for the whooping crane derives not only from its aesthetic qualities and rarity, but probably more directly with its identity as a symbol of the effort to save species from extinction. This value would not have been realized without extensive education efforts. Finally, increasing demands for use of this endangered species, which brings economic benefits, have raised concerns about the effects of these appreciative uses upon the well-being of the species. The issue of disturbance management is discussed elsewhere in this Plan.

G. General Conservation Measures

Before the mid 1950's, four significant events helped protect whooping cranes. The single most significant piece of protective legislation for whooping cranes was the Migratory Bird

Treaty Act between the United States and Great Britain (Canada), which was ratified by Congress on December 8, 1916. This Act assured legal protection for migratory bird species in Canada and the United States and provided a basis for preventing the hunting of species requiring complete protection.

The significance of the establishment of WBNP in the Northwest Territories in December 1922 (Raup 1933) was not realized until three decades later when the whooping crane nesting grounds were discovered there (Allen 1956). WBNP is a vast boreal forest and muskeg area (4,288,542 ha) set aside by the Canadian government (Raup 1933) as a preserve and management area for the wood bison (Bison bison athabascae). The portion of the Park occupied by nesting whooping cranes is primarily located northwest of the intersection of the boundaries of Saskatchewan, Alberta, and the Northwest Territories (Kuyt 1978b).

Aransas NWR was established in 1937 to protect the whooping crane and other wildlife of coastal Texas (Stevenson and Griffith 1946, Howard 1954). The Refuge includes 22,148 ha of Blackjack Peninsula and adjacent properties, and provides essential wintering habitat for whooping cranes. On Matagorda Island another 44,606 ha in State and Federal ownership, is managed in conjunction with Aransas. For additional protection, 5,236 ha of adjoining wetlands known as the Proclamation Boundary have been closed to hunting.

In the 1940's, many questions regarding the life history and ecology of the whooping crane were unanswered. The Service and the National Audubon Society (NAS) attempted to remedy this situation by setting up the Cooperative Whooping Crane Project. The goal of this project was to achieve species survival and population growth through increased protection and sound management. Robert P. Allen became the principal investigator; his studies culminated in the monograph The Whooping Crane (Allen 1952) published by the National Audubon Society in 1952.

This monograph established a foundation for subsequent research and management. The interest of many private citizens and organizations; the dedicated efforts of Federal, State, and Provincial personnel in the United States and Canada; the awakened concern of people along the migration route; and newspaper accounts alerting hunters to avoid mistaken shots were all important by-products of the heightened awareness stimulated by Allen's study.

In April, 1985, Bert Tetreault, Director General of the Canadian Wildlife Service and Robert A. Jantzen, Director of the U.S. Fish and Wildlife Service signed a memorandum of understanding (MOU) entitled Conservation of the Whooping Crane Relating to Coordinated Management Activities (Lewis 1991). The MOU provides a more formal structure to the cooperative working relationships that have characterized these two nations' joint efforts in management and research of whooping cranes. Under the new agreement, each Service appointed an employee to be responsible for inter- and intra-nation coordination of whooping crane management and research. The MOU discusses disposition of birds and eggs, postmortem analysis, population restoration and objectives, new population sites, international management, recovery plans, and consultation and coordination. The MOU was renewed for another 5 years in April 1990.

In 1985, a plan for Federal-State Cooperative Protection of Whooping Cranes was approved by the U.S. Fish and Wildlife Service and 13 States where whooping cranes occurred (Lewis 1992). The cooperative plan describes proposed response options when whooping cranes are observed in hazardous situations due to avian disease outbreaks, environmental contaminants, or hunting activities, or when these cranes are found injured, sick, or dead. Plan objectives are to provide added protection to whooping cranes, especially during migration, and to increase the opportunities to recover and rehabilitate birds found injured or sick. A similar plan was implemented in Canada in 1987.

A whooping crane health management workshop was organized in 1992 by the National Wildlife Health Research Center and ICF. Participants included the veterinary and wildlife disease specialists working with whooping cranes. Uniform health management protocols were established for disease monitoring and captive and wild flocks and for pre-release and pre-transfer disease screening. Unpublished information was collated on disease research. Research needs were identified and prioritized including avian tuberculosis, Eastern Equine Encephalitis (EEE), and crane herpes. Development of a centralized, computerized database on whooping crane mortality was initiated. A Health Advisory Team was established with a clinical and research veterinarian identified to coordinate input and serve as official advisors to the recovery team. The group should continue to meet periodically to evaluate progress and address future needs.

H. AWP Management And Research

Migration Monitoring: Although a number of migration sightings have been reported and compiled over the years (Allen 1952, Sutton 1967, Walkinshaw 1973, Archibald et al. 1976, Asherin and Drewien 1987), few were confirmed. In order to protect migrating whooping cranes from disease outbreaks and other potential hazards, and to compile information on the characteristics and locations of stopover sites, Service initiated a migration-monitoring program in 1975. This program alerts key personnel about sightings so that reports can be verified, stopover sites described, and the birds kept under protective surveillance by State and Federal personnel. This monitoring program is now coordinated with reporting networks of the CWS, States, and provinces along the migration corridor.

Flightless young whooping cranes were captured and marked with colored plastic legbands in WBNP from 1977 through 1988 (Kuyt 1978a, 1979a, Drewien and Kuyt 1979). Forty-eight percent of the 133 birds in the AWP were still individually identifiable in the summer of 1991. This marking program provided a wealth of information on whooping crane biology, including the summering locations of subadults, the dynamics and habitat-use of wintering subadult flocks, age specific survivorship, the age of initial pairing and breeding, reproductive histories, and the identification of stopover sites, and wintering and breeding territories used by specific pairs (Kuyt 1979b, 1981a, 1981b, Bishop and Blankinship 1982, Bishop 1984). The presence of marked birds provided more precise information on migration chronology, and yielded information on several events which would have otherwise gone undetected (Stehn 1992). Other information gained from the banding studies included the ability to develop a studbook on a fairly large segment of the wild population, tracing the reproductive histories of many of the birds including mate switches and probable deaths. This data provides valuable insight into the relatedness and genetic

diversity of the wild flock and may be of assistance in evaluating potential inbreeding effects in the future.

Radiotelemetry techniques were first tested on cross-fostered whooping cranes in the RMP (Drewien and Bizeau 1981). Beginning in 1979, flightless young were captured and marked with plastic legbands to which miniature radio transmitters (45-60 g) were attached. Local movements of the radio-tagged birds were monitored on summering and wintering areas and several individuals were followed during their fall migration between Grays Lake NWR in southeastern Idaho and Monte Vista NWR in south-central Colorado. No adverse effects were noted from capturing, banding, and radio-tagging young whooping cranes (Drewien and Bizeau 1981).

On the basis of these preliminary studies, a cooperative Service-CWS-National Audubon Society radio tracking program was initiated for birds in the AWP to determine various aspects of migration ecology, including habitat characteristics, behavior, and sources of mortality. During each summer 1981-1983, small solar-powered transmitters were placed on several prefledged whooping cranes captured during the routine color-banding operation in WBNP (Kuyt 1979a, 1979b, 1992). Data were obtained on three southbound and two northbound migrations. Most information involved the individuals or family groups actually being followed, but data were also accumulated on other migrating whooping cranes encountered during the project.

The successful tracking project resulted in important information concerning migration routes, migration timing, flight methods and speed, stop-over locations and staging areas, habitat use, social behavior, activity budgets, predator/disturbance reactions, and sources of mortality (Howe 1989, Kuyt 1992). Perhaps the most important result obtained from this tracking project has been documenting mortalities on the breeding grounds (wolf predation) (Kuyt et al. 1981), during migration (power line collisions), and on the wintering grounds (predation and disease). Two of nine radio-marked whooping cranes died within the first 18 months of life as a result of powerline collisions (Kuyt 1992). Similar valuable information has been acquired on migration and behavior of whooping cranes in the RMP (Drewien and Bizeau 1981, Asherin and Drewien 1987, Drewien et al. 1989).

Additional powerline construction, throughout the principal migration corridor, will undoubtedly increase the potential for collision mortalities. Tests of line marking devices, using sandhill cranes as surrogate research species, have identified techniques effective in reducing collisions (Brown and Drewien 1994a, 1994b, Morkill and Anderson 1992). Lines should be marked in areas frequently used by whooping cranes. New line corridors should avoid wetlands or other crane use areas.

Migration Habitat Management And Research: Based on a preponderance of sightings along the central Platte River in Nebraska during 1820-1948, Allen (1952) believed that whooping cranes made that area a major stopover, remaining in the area for some days. In 1978, the U.S. Fish and Wildlife Service designated an 88 km portion of the Platte River in central Nebraska as critical habitat.

As a result of reduced channel width, loss of adjacent wet meadows, and encroachment of the channel by woody vegetation brought on by diversion and storage of water for irrigation

and power generation (U.S. Fish and Wildlife Service 1981), 128 km of river channel whooping crane habitat have been lost. In the remaining 120 km of the Platte River channel that crosses the breadth of the migration path, there has been a 58 to 87 percent reduction in channel area due to encroachment of woody vegetation and a 70 percent loss in the average annual flow since 1930. As much as 97 percent of suitable crane roosting habitat has been lost in some river segments. Over 73 percent of native grasslands and wetlands adjacent to the river channel have been lost due to declines in river flows, construction of drainage systems, and conversion to cropland (Currier et. al. 1985).

Considering the significant loss of river channel and adjacent wetland habitat, the need to prevent further deterioration of habitat was identified by the U.S. Fish and Wildlife Service (1981). The findings of the Platte River Ecology Study suggest that a long term goal should be to establish management areas under public ownership or otherwise managed specifically for cranes. These areas would be managed to prevent further channel shrinkage and encroachment by woody vegetation.

Along the Platte River, roosting habitat suitability criteria (Ward and Anderson 1987, Armbruster 1990) combined with hydraulic simulations of Instream Flow Incremental Methodology (IFIM) have been used to identify the relationship between river discharge and roosting habitat (Platte River Management Joint Study 1990, Ziewitz 1992). The IFIM consists of a collection of computer models including the Physical Habitat Simulation Model and analytical procedures designed to predict incremental changes of habitat resulting from incremental changes in river discharge. The models that have been developed with this methodology are based solely on physical features of Platte River roosting habitat. The purpose of this application is to characterize the relationship between river discharge and the quantity and quality of whooping crane roosting habitat based on physical habitat parameters within the channel. The models are designed to be used as a tool for evaluating water management alternatives for roosting habitat on the Platte River and in selecting a river discharge that will provide the necessary quantity and quality of roosting habitat.

A river management plan prepared by the Biology Workgroup of the Platte River Management Joint Study (a group of representatives from the U.S. Fish and Wildlife Service, Bureau of Reclamation, Corps of Engineers, States of Wyoming, Colorado, and Nebraska, water development interests, and environmental groups) identified management alternatives that could be implemented in the Platte River basin as an aid to future management direction (Platte River Management Joint Study 1990). Currier et al. (1985) and Strom (1987) describe management programs to preserve, rehabilitate and restore river habitat. Other research conducted along the Platte River (Hurr 1983, Henszey and Wesche 1993, Wesche et al. 1990) indicates river discharge and stage is a dominant factor affecting groundwater levels in wet meadow grasslands. This information has implications to river flows required to maintain the wet meadows used by cranes.

The Platte River Whooping Crane Habitat Maintenance Trust (Trust) began implementing their habitat restoration program in the early 1980's. The Trust is acquiring land through fee title acquisition and conservation easements. Restoration activities include clearing and maintaining river roost sites free of trees and shrubs and restoring and rehabilitating wetland meadows and marshes adjacent to the river channel. Human activity near river roosts and wetland meadows is restricted during the migration periods.

The Nebraska Game and Parks Commission, acting under authority of a State law that allows protection of instream flow for wildlife, has identified and will be requesting protection of specific instream flows that will help maintain remaining river roosting habitat and adjacent wetland meadows. The Nebraska Department of Water Resources must issue a water right permit for wildlife if existing instream flows are to be protected from future diversion. Efforts are being made by the U.S. Fish and Wildlife Service, Nebraska Game and Parks Commission, the Trust, and environmental groups, through a Federal Energy Regulatory Commission power generation relicensing process, to secure the release of water stored in Lake McConaughy into the Platte River. Such releases would supplement natural flows, increasing the quantity and quality of whooping crane roosting habitat and helping maintain wetland meadows.

The Service has been studying availability of suitable migration stopover habitat within the United States (Stahlecker 1988, 1991, 1993) and this work should continue over the next few years.

Wintering Grounds Research: Despite intensive studies of whooping cranes on the wintering grounds by Allen in the late 1940's, some important questions remained unanswered. More detailed information was needed on the food habits, on food availability in relation to climatic conditions, on spatial requirements and territorial behavior in an expanding population, and on the effects of increasing human activities in and around the cranes' habitat. With more of this information available, better management planning and evaluation would be possible.

A study of potential whooping crane food organisms and related physical factors was conducted in 1963 and early 1964 by Bill Van Tries and Gordon Folzenlogen of the Service. In November 1970, the NAS assigned David R. Blankinship to conduct research on wintering whooping cranes at Aransas NWR and adjacent islands and peninsulas. Findings on territorial, subadult flocks, adult-young relationships, feeding ecology, parasites, and other aspects of wintering ecology have been published (Blankinship 1976, Forrester et al. 1978, Bishop and Blankinship 1982, Bishop 1984).

Hunt (1987) studied upland habitats at Aransas NWR in the early 1980's. Objectives were to identify environmental conditions associated with the use of upland habitats by whooping cranes and sandhill cranes, to determine the effects of refuge management practices on upland habitat, and to determine the relative importance of food items consumed by cranes in the uplands. Based on fecal analysis, foods utilized included blue crabs, clams (Tagelus spp.), snails (Melampus coffeus), acorns, and wolfberry. Whooping cranes used portions of upland pastures which were open, close to the wetland edge, and away from sources of human disturbance. Periodic upland burning increased the visual openness of the habitat, oak stem density, and the availability of acorns (Hunt 1987).

The wintering territories of whooping cranes on the Texas coast place the birds in close proximity to several human-induced disturbance factors. These factors include tour boats with the purpose of watching cranes, 24-hour boat and barge traffic along the GIWW, recreation and commercial (including hunting, angling, crabbing, and oystering) traffic, and aerial overflights. The extent to which whooping cranes are exposed to the above factors varies among the different use localities because restrictions and practices differ in the

various private and public land ownerships. Studies have been underway to determine the amount and effect of disturbance in wintering areas (Lewis and Slack 1992).

In the winter of 1985-86, Mabie et al. (1989) examined the response of four whooping crane family groups on Matagorda Island to several staged hunting and boating activities. The study examined the behavior of whoopers during two hour intervals which involved a staged disturbance (hunter in outboard, hunter in airboat, or airboat harassment) during the first hour. Direct harassment by airboat caused the only significant difference in behavior pattern (percent of time alert) when compared to control observations. Individual family group responses varied greatly, with cranes responding to disturbances at distances ranging from 25 to 550 m. Whooper response ranged from alert posture to walking away to flying away to a maximum distance of 2,150 m. Whooping crane response was generally short-term, with a return to normal behavior patterns by the second hour of observation.

Irby (1990) observed whooping cranes on Welder Flats for 365 hours during 1990, using scan sampling and focal bird sampling techniques, and noted all events during that period which caused disturbance to whooping cranes. He noted seven disturbances related to hunters, which totalled 18.75 minutes in duration (alert or response behavior). Crane response included: flight (4 instances), walking away (1), and alert posture (2). Irby noted six disturbances related to fishing, totalling 5 minutes in duration. Crane response included flight and walking (1) and alert posture (1). Commercial boats caused five disturbances, totaling 11 minutes. Responses included walking away and flight (1), walking away (1), and walking away and returning (3). Of the 365 hours of observation, cranes spent 47 minutes responding to non-observer human-induced disturbance.

Irby (1990) made several recommendations resulting from his observations. Barge mooring may represent a dangerous threat. A coordinated plan needs to be developed to protect the area from pollution, and to designate safe barge mooring areas. Refuge and coastal wetland users should be encouraged to minimize disturbance to whoopers. Boaters should be educated about damage caused to submerged vegetation by boating activities. The support of the private landowner in minimizing disturbance and maximizing protection should be recognized and encouraged.

It is difficult to assess the total impacts of disturbance upon whooping cranes in terms of fitness, productivity, and survival. Some birds habituate to boat activity (Stalmaster and Newman 1978, Knight and Knight 1984). As the AWP continues to expand, a decrease in territory sizes and expansion into new wintering areas is likely to continue. Any increase in frequency or severity of disturbance could be compounded by the effects of increased population density and/or exposure to the disturbances. Levels of disturbance should be monitored on the wintering grounds and steps taken to minimize detrimental activities.

Two graduate students from Texas A and M are studying whooping crane winter foods under the direction of Dr. Doug Slack. Felipe Chavez-Ramirez started in September 1992 an investigation of the standing crop biomass of blue crabs, clams, and wolfberry berries and evaluating human and wildlife competition for these principal crane foods. In 1993, Jay Nelson initiated a study to determine the nutritive composition of the winter foods and compare that to the commercial rations used for the captive flocks.

Wintering Grounds Management: Management of Aransas NWR is a sizeable and complex operation (Johnson 1976). Prime habitat is limited and natural foods may at times be in short supply. Two 40-ha fenced enclosures were developed during 1964-1968, in which various cereal and root crops were grown. Some whooping crane use of these fields occurred but most food crops intended for whoopers were consumed by the more numerous sandhill cranes and Canada geese (Branta canadensis) (Shields and Benham 1969). Another innovation was the diking of a 28-ha impoundment equipped with a high volume, low-lift pump designed to bring large quantities of saline water and marine life into the basin; the exit of live food items was prevented by screens at spillway outlets. Limited use by whooping cranes was achieved during one winter when they were attracted to the site by "bait" grains, but in subsequent years whooping cranes did not use the artificial impoundment.

During the mid-1960's, whooping cranes were attracted by grains spread for their use. Such "baiting" has since been avoided because concentrating the birds increases the potential for a disease outbreak or the spread of parasites. However, baiting could be attempted to attract whoopers from the tidal areas in certain emergency situations, such as *during oil or chemical spills, or periods of food scarcity.*

Prescribed burning is used to reduce height and density of grasses, remove brush, and to modify plant composition on uplands to make them more attractive to whooping cranes. This management was attempted in the past by mechanical cutting and grazing by livestock. Burned areas are almost immediately utilized by whoopers (Hunt 1987). Currently, 10 prescribed burn units averaging 564 ha are located in the crane area at Aransas NWR. Depending on the acorn crop, the units are burned on a 3-year rotation. Additional burning is done on Matagorda Island, as well as on private lands on San Jose Island and Welder Flats.

The most complete counts of the AWP are made during winter. Aerial censuses are made weekly from the time the first whooping cranes appear, less frequently in mid-winter, and again weekly until the last cranes depart. Flights provide information on mortality, habitat use, pair formation, territory establishment, and population age structure by identifying all color-banded birds present. These flights, and an irregular schedule of boat patrols, serve to alert the refuge staff to hazards or harassment of cranes resulting from human activity, including accidental spills along the GIWW. If a crane is determined to be "missing," then a ground search is initiated to locate the carcass. Additional protection of some wintering habitat outside Aransas NWR has been provided by National Audubon Society's leasing Ayres and Roddy islands, the Dunham Island area, and portions of Rattlesnake and Matagorda islands from the State of Texas. The leasing arrangement substantially reduces the potential for disturbing or harassing cranes wintering in these areas.

Whooping cranes use marshes bordering Matagorda Island. In 1942, the Federal government purchased approximately 7,700 ha of the Island, and leased 2,400 ha from the State of Texas, to establish an airbase and bombing range. This area was declared excess property in 1975. Administration of the property was transferred to the Service as part of the National Wildlife Refuge System in 1978. In 1988, the Service completed purchase of 2,232 ha on the south end of Matagorda Island. A new agreement between Service and the

State of Texas for joint management of the entire island (60.8 km long by 1.2 to 7.2 km in width) is awaiting signature.

Construction of the GIWW in the early 1940's, through the heart of the marshes on Aransas NWR, and subsequent erosion by wind and boat wakes, resulted in 11 percent loss of wintering habitat (Sherrod and Medina 1992). Boats and barges plying the GIWW create wakes and surges which continuously erode the marsh back from the channel (U.S. Army Corps of Engineers [Corps] 1988). Between 1959-1992, volunteers placed over 57,000 sacks of cement to protect 2,652 m. of shoreline. In 1992, the Corps placed 610 m of interlocking cement mats to stop erosion. Stehn (pers. comm 1993) reported erosion occurring along 8.5 miles of critical habitat shoreline. The Corps agreed in 1993 to armor approximately 3 miles of the most critically eroding shoreline in 1993 and 1994. Thereafter, the Corps will continue to armor 2,000 feet annually until all areas are adequately protected by the means identified in the Corps' Section 216 Study which is to provide a permanent solution to the habitat erosion problem.

Deposition of dredged material from periodic maintenance dredging of the channel has destroyed additional marsh and, unintentionally, created some new marsh. Dredged material disposal sites along the GIWW which would cause little or no damage to whooping crane habitat have all been utilized and the problem of future disposal of spoil is critical.

The Corps is now evaluating beneficial uses of dredge spoil to create new whooping crane coastal marsh habitat similar to that created by Mitchell Energy and Development Corporation in Mesquite Bay. In the summer of 1991 Mitchell Energy created a dike around 4 ha of open shallow bay and filled the area with dredge spoil. The area was then planted with vegetation and the first whooping crane use was documented in January 1992.

I. Captive Propagation

Research and Propagation at PWRC: Before research was carried out at PWRC, successful attempts to propagate whooping cranes involved only four birds--two females (Josephine and Rosie) and two males (Crip and Pete) (McNulty 1966, Doughty 1989). Josephine was the last survivor of the nonmigratory, southwestern Louisiana population. Crip, Pete, and Rosie, flightless due to injuries, were from the migratory population (McNulty 1966, Maroldo 1980).

Erickson (1961) analyzed the Aransas winter population counts from 1938-1960, and prepared an administrative report entitled "Production and Survival Of The Whooping Crane". This analysis revealed three important characteristics of the wild population that were later confirmed by Novakowski (1966): (1) principal production was apparently derived from a fairly stable cohort of long-lived adults, (2) among birds returning to Canada, mortality was highest in the subadult cohort, and (3) because subadult mortality was apparently limiting recruitment into the breeding population, the population would remain insecure until this mortality was reduced. Based on these findings, Erickson proposed to bolster the wild population through captive propagation and the release of captive-produced stock. However, he cautioned that before stock was obtained from the wild, safe and effective procedures should be developed using sandhill cranes as research surrogates.

Experimentation with sandhill cranes began in 1961. Immature lesser and greater sandhill cranes were captured on the wintering grounds in 1961 and 1962, respectively, and greater sandhill crane eggs and downy chicks were collected in southeastern Oregon in 1962. These initial studies indicated that egg collecting was the safest and most convenient method of obtaining and transporting wild stock. Only eggs were taken from the wild in subsequent years at Malheur NWR, Oregon and Grays Lake NWR, Idaho, several locations in peninsular Florida, and Jackson County, Mississippi.

The experimental flock was initially quartered in temporary facilities at Monte Vista NWR, Colorado. However, in 1966 Senator Karl E. Mundt sponsored a supplemental appropriation to establish the Endangered Wildlife Research Program and to develop permanent facilities at the PWRC in Laurel, Maryland. The Whooping Crane Conservation Association was influential in acquiring the first project funding at PWRC. The advantages of this location, organizational arrangement of this program, and species receiving initial attention were summarized by Erickson (1968). The single whooping crane and sandhill cranes were transferred from Colorado to Maryland in the spring of 1966. This bird, a male eventually named CAN-US, was captured as a chick in WBNP in 1964 after it was observed that his wing was severely injured (Novakowski 1965).

Egg-taking experiments with sandhill cranes indicated that nest desertion was negligible and population productivity was relatively unaffected when single eggs were removed from two-egg clutches. It had previously been noted that cranes normally lay two eggs but rarely fledge two chicks. Observations on the breeding grounds by Novakowski (1966) confirmed that whooping cranes generally follow this pattern. It appeared that a single egg could be removed from each two-egg clutch with the same favorable results experienced with sandhill cranes.

CWS and the Service obtained eggs from nests in WBNP in 1967 to 1971, and 1974 to further augment the PWRC population, and in 1975 through 1988 to provide eggs for the Grays Lake cross-fostering experiment (Table 2). Egg transfers to PWRC were resumed in 1982 and initiated at ICF in 1990 to increase the size and genetic diversity of the captive flock.

Between 1967 and 1993, 181 eggs were taken from the wild to the captive sites (Table 2). Chicks raised from these eggs currently form the nucleus of the breeding flocks being maintained at PWRC and ICF. Egg collections and subsequent propagation efforts have been described elsewhere (Carpenter et al. 1976, Carpenter and Derrickson 1981, Derrickson and Carpenter 1981, Erickson 1975, 1976, Erickson and Derrickson 1981, Kepler 1976, 1978, Kuyt 1976a, 1976b).

Erickson (1976) and Kuyt (1976a, 1981a, 1981b) noted that egg removals have not adversely affected the productivity of the wild population. Between 1967 and 1992, the AWP increased from 48 to 136, and the number of breeding pairs increased from 9 to 40. Although some propagation techniques developed for sandhill cranes can be applied to whooping cranes, the latter have required certain procedural modifications. Whooping cranes have been more difficult to raise than sandhills, and most mortality has occurred within one month of hatching as a result of bacterial infections, coccidiosis, congenital

abnormalities, and leg disorders resulting from rapid growth (Kepler 1978). Carpenter and Derrickson (1981) summarized all mortalities in the captive flock from 1967 to 1981.

Eggs were first produced at PWRC in 1975, when one female laid three eggs (Table 3). Although two females produced eggs when they were 5 years old, most captive females have not laid until they were 7-11 years old (Table 4). Factors identified as responsible for delaying reproduction in the captive flock include rearing conditions, dominance relationships, age of separation of potential pairs from bachelor flock, sexual compatibility, inadequate pen size, and stress associated with handling and disturbance (Kepler 1976, 1978, Derrickson and Carpenter 1981).

Between 1975 and 1993, the captive flock at PWRC produced 356 eggs (Table 3). Seventy-three whooping crane eggs were transferred from PWRC to Grays Lake between 1976 and 1984. To date, annual production has been primarily limited by the number of breeding pairs, and egg fertility. Although productive pairs at PWRC exhibit copulatory behavior, and males regularly attempt to mount their mates, successful natural copulations were not observed until 1991. In the spring of 1991, a pair of full-winged, behavioral conditioned, captive-reared whooping cranes, laid the first fertile egg at PWRC without artificial insemination. The Service believes naturally fertile pairs will lay more eggs than artificially inseminated birds. Natural fertilization reduces the risk of injury due to handling. To avoid imprinting problems, PWRC now rears chicks outdoors with a pair of whooping cranes or hand-rears them in visual and auditory contact with a subadult whooping crane role model. In 1992, five additional pairs produced five chicks by natural breeding. To acquire fertile eggs from badly imprinted or handicapped individuals, the females have been artificially inseminated using a variation of the massage technique (Gee and Temple 1978). In order to condition pairs to this procedure, the collection of semen from males and the handling of females are initiated well in advance of laying. Females are inseminated from the time their pubic bones begin to separate until laying ceases. Throughout this period, females are routinely inseminated three times per week and after each oviposition.

From 1975 through 1981, 55 of 61 eggs (90 percent) were fertile, from 1982 through 1986, 89 of 97 eggs (92 percent), and from 1987 through 1992, 41 of 53 eggs (77 percent) were fertile from whooping cranes artificially inseminated. Fertility of artificially inseminated eggs over the entire period through 1992 averaged 86 percent. Between 1987 and 1992, the PWRC flock produced 74 eggs (50 fertile). From these 50 and 43 other fertile eggs obtained from WBNP, PWRC fledged 49 birds. During the same interval, PWRC shipped 22 birds to ICF in 1989 to help establish a second captive flock and 6 birds to Florida for release in 1993. The flock was split to reduce the risk of disease outbreaks decimating the entire captive population.

Early attempts to artificially incubate whooping crane eggs suggested problems with less than optimum incubation regimes. Results obtained in 1978 supported this conclusion, because (1) hatchability of the 8 eggs retained at PWRC and incubated under sandhill cranes was 88 percent, (2) of 11 fertile eggs which were incubated artificially before their transfer to GL, only 5 hatched; and (3) the 6 fertile eggs that did not hatch at GL contained 4 late dead, and 2 early dead embryos. Hatchability of whooping crane eggs incubated by cranes exceeds that of eggs incubated in incubators. As a result, since 1979 all whooping crane

Table 2. Hatching and fledging success of whooping crane eggs transferred from WBNP (WBNP) to PWRC and ICF, 1967-1993.

Year[a]	No. Pairs	No. Eggs Transferred		Minimum No. Eggs Remaining	No. Eggs Hatched			No. Chicks Fledged	
		PWRC	ICF	WBNP	PWRC[b]	ICF	WBNP	PWRC	ICF
1967	9	6		11	5		10	4	
1968	10	10[c]		10	10[c]		10	7	
1969	12	10		12	9		11	5	
1970	15	0		27	1		6	0	
1971	13	11		13	9		11	3	
1972	16	0		26	0		6	0	
1973	14	0		26	0		3	0	
1974	15	13		15	9		15	4	
1975	16	--		15	--		11	-	
1976	16	--		16	--		14	-	
1977	17	--		16	--		14	-	
1978	15	--		14	--		10	-	
1979	19	--		18	--		14	-	
1980	19	--		22	--		15	-	
1981	17	--		17	--		10	-	
1982	17	2		19	2		12	1	
1983	24	2		23	2		15	2	
1984	29	3		32	1		21	1	
1985	28	4[d]	27	1		20	1		
1986	29	4		28	2		25	2	
1987	32	12		33	7		31	5	
1988	31	14		33	8		25	7	
1989	31	15		34	6		21	3	
1990	32	0	12[d]	47	0	11	24	0	8
1991	33	16	0	36	6	0	21	4	0
1992	40	10	11	48	9	10	35	7	7
1993	44	16	10	59	15	9	35	13	8
Totals		148	33	677	102	30	445	69	23

a No eggs of wild origin were transferred to PWRC in 1972, 1973, and 1975-1981. Limited transfers were resumed in 1982 to increase the size and genetic diversity of the captive flock. Transfers were increased in 1987 to build the captive flocks.

b Unhatched eggs are opened and examined.

c Includes one wet, newly-hatched chick which was removed from the nest (instead of the other egg) to avoid chilling.

d Two eggs were infertile and sent only for examination; a third had an embryo that died in incubation.

Table 3. Size and productivity of the whooping crane captive flock at PWRC, 1975-1993.

Year	All Birds	Females Laying	Total Eggs[a]	Eggs retained at PWRC			Chicks Fledged
				No.	Fertile	Hatched	
1975	20	1	3	3	2	1	0
1976	19	2	5	3	1	1	1
1977	21	4	22	8	4	3	2
1978[b]	22	3	23	8	8	7	3
1979[c]	26	4	21	16	10	8	4
1980	22	2	6	4	1	0	0
1981	20	2	11	11	5	3	1
1982	26	5	28	15	12	9	6
1983	35	5	34	22	18	14	8
1984	32	5	31	21	16	12	4
1985	38	3	13	13	8	7	6
1986[d]	38	0	0	--	--	--	-
1987	41	5	7	7	3	2	1
1988	46	6	15	15	8	7	3
1989	32	5	19	19	14	9	8
1990	35	4	14	14	5	4	3
1991	40	5	21	21	9	5	2
1992	49	8	48	48[e]	11	9	8
1993	49	8	35	35	16	15	10
Totals	611	77	356	283	151	116	70

a Includes 73 eggs transferred to Grays Lake National Wildlife Refuge in 1976-1984. Fertility determined for unhatched eggs by examination of egg contents. Examination occurred after full-term incubation and eggs containing no detectable embryo were considered infertile, therefore, the number of fertile eggs listed is considered a minimum estimate.

b All eggs retained at PWRC were incubated and hatched under sandhill cranes and chicks were "foster-parent" reared. All eggs transferred to GL were artificially incubated until transfer.

c All eggs retained at PWRC were incubated under sandhill cranes and chicks were hand-raised or foster-parent raised by sandhill cranes. All eggs transferred to GL were incubated under captive pairs of sandhill cranes at Patuxent until transfer this year and subsequent years.

d No eggs were produced in 1986. Breeding birds were moved temporarily to pens in Summer 1985 during construction of new pens. The birds were moved into the new pens in November 1985. These movements were believed to be the disturbance that disrupted the 1986 breeding cycle.

e Six new pairs broke the eggs (19) they produced.

Table 4. Age of whooping cranes when they first produced eggs, PWRC, 1975-1993[a].

Age (years)	Females[b]	Producing Females[c]	Percent Producing
5	28	5	17
6	22	8	36
7	15	8	53
8	13	10	76
9	10	9	90
10	9	9	100

a Does not include birds transferred between centers before maturation. Transfers delayed egg production.
b Females reaching or passing through that age class by 1993.
c Females producing eggs in that age class.

eggs have been incubated under sandhill cranes or whooping cranes. Since these modifications were undertaken, hatchability and chick survival has equaled that observed in eggs and chicks from the AWP (Table 2).

Between 17 September and 4 November, 1984, seven (two male, five female) whooping cranes in the captive flock at PWRC died from EEE. These losses represent a serious setback to the captive breeding program because five of the birds were females. The January 1985 sex ratio in the surviving adult captive population was 10 males to 4 females. Sandhill cranes at PWRC also were exposed to the virus, but no mortality occurred (Carpenter et al. 1987). Whooping cranes appear especially susceptible to EEE, consequently the potential impact of this disease will be considered when selecting any site for additional whooping crane populations.

Thirteen of the 32 whooping cranes at PWRC were exposed naturally to the virus and all developed antibody titers. Birds that survive an EEE infection become immune, thus, the use of an EEE vaccine should reduce the risk of this disease in the future. Actions taken in 1985 and continued annually to prevent another outbreak of EEE at PWRC included: (1) a surveillance and control program for the principal mosquito (Culiseta melanura), vector of the disease; (2) testing EEE vaccines and developing a more effective vaccine for whooping cranes; and (3) continuing serological monitoring of the captive flock for antibody titers. Now that the etiology of the whooping crane deaths at PWRC is known, it is expected the disease threat can be minimized at PWRC by initiating appropriate mosquito control measures and the use of EEE vaccines. However, the long-term efficacy of the vaccine is unknown and annual boosters shots are required. The Crane Health Advisory Team recommended that the cranes at ICF and PWRC be vaccinated but not the cranes at Calgary and San Antonio Zoo.

In September-October 1987 a mycotoxin in the commercially prepared crane feed poisoned about 240 of the 300 captive cranes at PWRC. Fifteen cranes died (5 percent of the flock),

including three whooping cranes. Laboratories found a trichothecene (mycotoxin) in the feed that may have been the toxic agent (Valente 1992). Since fall of 1987, Patuxent tests all feed. A small sample of the crane diets is fed to bobwhites (Colinus virginianus) before feeding the pellets to the cranes. Food consumption, body weight changes, and mortality in the quail are used to detect toxins in the feed.

At PWRC, Mississippi sandhill cranes (G. c. pulla) are reared for release to the wild. Although releases of parent-reared chicks have been successful, parent-rearing is labor intensive and occasionally results in excessive chick mortality. Development of an improved hand-rearing technique using live imprint models (conspecific cranes), stuffed brooder models and feeding puppets started in 1985. The technique was further refined in 1989 with the addition of costumed caretakers. The release groups of Mississippi sandhill cranes included: (1) parent-reared, (2) hand-reared and (3) a mixed group of hand-reared and parent-reared cranes. Survival one year has been high (average 83 percent). Another 35 birds were released in the winter of 1991-1992 and 40 in 1992-1993. Average survival declined to 60 percent in the 1992 release because of bacterial infection and increased predator pressures in the parent-reared cohort (25 percent survival). The annual survival increased in the 1993 release to previous levels (average 80 percent). A reproductive study of the released birds will continue into the mid-1990's.

A study of genetic diversity and relatedness in the whooping crane began in 1986 and data collection for three of four projects ended in 1991 (Dessauer et al. 1994, Gee et al. 1988, Jarvi et al. 1992, Longmire et al. 1992). Compared with other cranes, whooping crane diversity was about average in an electrophoresis study of blood proteins (0.041 -+ 0.021, Table 5); below average in band-sharing of nuclear restriction fragment length polymorphism of mini-satellite DNA (0.42); and about average in polymorphism of the major histocompatibility complex.

Other recent significant events include use of monensin as an improved treatment for disseminated visceral coccidiosis; a new platform terminal satellite transmitter and harnesses for cranes; successful tracking of cranes from northern Siberia to Iran, Afghanistan, and India; monitoring and characterizing incubation profiles in nesting sandhill cranes; building a new computer control incubator capable of simulating conditions found in the nest; and some progress in embryo cell cryopreservation. The pen facilities at PWRC are now completely state-of-the-art. The low maintenance needs of these new facilities should help establish breeding pairs on a territory without the disturbances associated with pen maintenance experienced in earlier complexes.

Propagation At ICF: The International Crane Foundation is a private conservation organization dedicated to the preservation of cranes worldwide. Captive propagation expertise was developed during the 1970's with several crane species, including whooping cranes (Doughty 1989).

In late 1989, ICF received from the Rocky Mountain population an injured adult male (Napolean) whose wing had been amputated and 22 whooping cranes from PWRC. Two cranes died shortly after their arrival. No eggs were laid by the two experienced pairs in 1990, probably due to the disruption caused by the move. Cranes, especially whooping cranes, are sensitive to disturbance and pen changes (Mirande pers. comm.). In May of

1990, 12 eggs were transferred from WBNP to ICF, 11 were fertile and 8 fledged. Nine eggs were laid by three captive females in 1991, and one chick was parent-reared (Table 6).

In 1992, the same three breeding pairs produced 16 eggs (3 from natural copulation), and 6 were reared. Closed circuit TV proved effective in (a) eliminating egg breaking by a pair that broke eggs in 1991, and (b) in monitoring and supervising the socialization of new pairs. Eleven eggs were received from WBNP, and 7 chicks fledged. One captive-produced chick was parent-reared, 4 were hand-reared, and one (together with 7 chicks from AWP eggs) was costume-reared. Costume-rearing refers to the use of a white crane-like costume worn by animal caretakers whenever they are around the birds. In this manner, cranes are never exposed to the human form and remain fearful of people. From the time of hatching, costume-reared whoopers are exposed to live whooping crane role models in adjacent pens to avoid imprinting problems. Eight of the costume-reared birds were sent to Florida in January 1993 for the reintroduction experiment. In 1993, three females produced 9 eggs and four chicks fledged. ICF also received nine fertile eggs from WBNP, eight hatched and all fledged. Four were sent as chicks to Idaho for use in the guide bird research. In August 1993, ICF held three breeding pairs, three mature females being re-paired to stimulate breeding, five other pairs nearing sexual maturity, a single adult male, four yearlings, and eight juveniles. ICF has the capacity to house 15 breeding pairs of whooping cranes. Research is ongoing to improve reproduction, rearing procedures, behavioral management, health care, and other topics which may directly benefit management and recovery.

J. The Cross-Fostering Experiment

For any species, the probability of extinction is largely determined by its abundance, fecundity, and distribution. Conventional management procedures for the whooping crane have been aimed primarily at increasing the size of the AWP population. Even though this population has increased substantially since the 1940's, it remains vulnerable due to its relatively restricted breeding and wintering distributions. It was recognized that survival prospects for the whooping crane would be greatly enhanced by establishing additional, disjunct populations. Although several approachesto establishing additional breeding populations had been proposed, the technique which seemed most worthy of consideration was cross-fostering whooping cranes to sandhill crane foster parents. This procedure was initially proposed in the 1950's by Fred Bard, a former Director of the Saskatchewan Museum of Natural History. By this method, whooping crane eggs from the wild or from captive breeders would be placed in sandhill crane nests, and the sandhill cranes would incubate, hatch, rear, and introduce the whooping crane chicks into the wild.

Cross-fostering is relatively simple and could be applied in various areas formerly within the whooping cranes breeding range. Furthermore, migration routes, stopover points, and wintering locations could be determined in advance by banding and subsequently observing potential foster-parent pairs. Despite these obvious advantages, the technique raised a number of unanswered questions: Would the food items used by sandhill cranes be nutritionally adequate for whooping cranes? Would altitudinal differences between the source of the eggs and the transport point affect hatchability? Would whooping crane chicks become sexually imprinted upon sandhill cranes, and eventually select a sandhill mate? These and other questions could only be answered by experimentation (Drewien and Bizeau 1978, Drewien and Kuyt 1979).

Table 5. Indices of diversity in population samples of cranes from the wild.

Crane Taxon & Sample Size	Heterozygosity Direct Count[a]	Heterozygosity Estimates[b]	Alleles/Polymorphism Locus[a]	Alleles/Polymorphism Percent
Whooping 14	0.048+0.024	0.045+0.023	1.17+0.08	20.9
Mississippi sandhill 7	0.024+0.014	0.050+0.033	1.17+0.10	12.5
Greater sandhill 17	0.067+0.028	0.071+0.031	1.38+0.13	29.2
Florida sandhill (Okefenokee deme) 10	0.028+0.016	0.037+0.022	1.13+0.07	12.5
Florida sandhill 2	0.125+0.069	0.111+0.052	1.17+0.08	27.2
Siberian 9	0.032+0.016	0.031+0.015	1.17+0.08	16.7
Saurus Crane 6	0.028+0.019	0.036+0.026	1.13+0.09	08.3

a Means +/- Standard Error
b Unbiased Estimate
c 0.99 Criterion

Table 6. Size and productivity of the whooping crane captive flock at ICF, Baraboo, Wisconsin, 1989-1993.

Year	All Birds	Females Laying	Eggs	Fertile Eggs	Chicks Hatched	Chicks Fledged
1989	24	0				
1990	30	0				
1991	28	3	9	2	2	1
1992	39	3	16	8	6	6
1993	32	3	9	5	5	4
Totals	153	9	34	15	13	11

The opportunity to test cross-fostering occurred at Grays Lake NWR (GL) in Idaho, where studies on the greater sandhill crane had been in progress since 1969 (Drewien and Bizeau 1974). Between 1969 and 1974, over 700 cranes were captured and color-marked for investigations of nesting biology and seasonal movements (Drewien 1973, Drewien and Bizeau 1974). These studies revealed that sandhill pairs would tolerate considerable manipulation without deserting their nests, individual families showed regular seasonal movements, and young birds adopted the movement patterns of their parents. GL is on the western edge of the known historical range of the whooping crane, and many features made it an excellent site to test cross-fostering: (1) the Grays Lake marsh is large and includes excellent crane breeding habitat; (2) sandhill crane nesting densities are high; (3) nesting success ranged from 78-92 percent between 1969 and 1974, (4) nesting chronology of the sandhills at Grays Lake is similar to that of the whooping cranes in Canada; and (5) carcass analyses of sandhill cranes indicated minimal residues of organochlorines and heavy metals. Furthermore, color marking of the Grays Lake sandhills had demonstrated the birds made one, often prolonged stop at Monte Vista NWR, in Colorado's San Luis Valley, and wintered in the Rio Grande Valley in central New Mexico (Figure 4). This sandhill population thus enjoyed a maximum amount of protection by using national wildlife refuges for breeding, migration stopover, and wintering (Drewien and Bizeau 1978).

Drewien and Bizeau submitted a proposal in 1972 recommending use of the Grays Lake sandhills to test cross-fostering of whooping cranes. Following considerable debate and drafting of an environmental assessment, approval for the experiment was secured in 1974 from the Service and the CWS. Beginning in 1975 and continuing through 1988, whooping crane eggs (216) from WBNP were transferred to GL for placement under marked pairs of sandhill cranes (Table 7). Between 1976 and 1984, eggs (73) from the captive flock at PWRC were also transferred to GL. Details of the cross-fostering experiment have been discussed elsewhere (Drewien and Bizeau 1978, Drewien and Kuyt 1979, Drewien 1975-1983 and Drewien and Brown 1984-1990, Unpubl. Prog. Rept. Nos. 1-25, Whooping Crane Transplant Experiment, Idaho Coop. Wildl. Res. Unit, Univ. of Idaho, Moscow). Many of the initial questions raised by this technique (i.e., will proper migratory traditions be established? Will the cross-fostered whoopers adapt to the obvious habitat and dietary differences, etc.) have now been answered, and field observations indicate that behavioral incompatibilities between the two species generally prevent mixed species pairing and subsequent hybridization.

A rather low rate of release was achieved at GL due to small numbers of fertile eggs in some years and excessive mortality of young before fledging. In 1976, 1977, 1978, 1981, and 1986-1988 drought conditions prevailed during the brood-rearing season. Low water levels and dry conditions reduced available food supplies, and allowed coyotes access to large sections of the marsh. Most chick mortality can be attributed to inclement weather at the time of hatching, poor habitat and food conditions during some years, and coyote predation (Drewien and Bizeau 1978, Drewien et al. 1985). Sandhills at GL suffered similar reductions in productivity during these same years. Although subadult and adult mortality rates have been much lower, a number of birds have been lost to fence and powerline collisions (Brown et al. 1987), disease (Snyder et al. 1987, 1992, Stroud et al. 1986), predation (Windingstad et al. 1981, Drewien et al. 1989), and other causes. The high incidence of avian tuberculosis in the RMP indicates that whooping cranes may be particularly susceptible to this disease. Together, these mortalities and the restricted

number of eggs available for transplanting resulted in a relatively small population which peaked at 33 individuals in winter 1985.

The sex ratio was equal at fledging age among 22 cranes examined at WBNP and 6 cranes at GL. The data, based on chromosome identification in the blood, suggests that differential mortality rates are the basis for unequal sex ratios among adults in the RMP.

In June 1981, a captive, 3-year-old, parent-reared female whooping crane was transferred from PWRC to GL and placed on a wild male's territory (Drewien 1982, Unpubl. Prog. Rept. No. 17, Whooping Crane Transplant Experiment, Idaho Coop. Wildl. Res. Unit, Univ. of Idaho, Moscow: pp. 32-41). This experimental reintroduction was attempted to determine if it was possible to simultaneously augment the wild cross-fostered population, rectify the male-skewed sex ratio, and hasten the onset of breeding in the wild population.

It was assumed that the probability of pair-formation would be relatively high for several reasons, including: (1) released birds are initially subordinate to wild birds following release, a situation favoring male dominance and pairing; (2) the male at GL was sexually mature, and the female was old enough for pairing; and (3) numerous instances have been documented in which wild cranes have successfully paired with tame or captive individuals (Hyde 1968, Longley 1970, Nesbitt 1979). Previous experiments with sandhill cranes demonstrated that the transition period from captivity to the wild involved considerable learning and consequently occurred over a relatively extended period. In this particular release, it was assumed that this transition period would be ameliorated and shortened because if the two paired her mate would introduce her to foods, foraging methods, roosting areas, teach a proper response to potential predators, and ensure proper migration by the female.

Although the female rapidly adjusted to the wild and associated periodically with the male, a pair bond was never established. Successful migration by the unattached female seemed unlikely, therefore she was recaptured and returned to PWRC in October (Drewien and Clegg 1992). This experiment was repeated the following summer. In 1982, as in 1981, the female readily adapted to the wild environment, and her presence stimulated increased territorial activities by the male (Drewien 1983, Unpubl. Prog. Rept. No. 18, Whooping Crane Transplant Experiment, Idaho Coop. Wildl. Res. Unit, Univ. of Idaho, Moscow: pp. 8-10). Unfortunately, the experiment was terminated early when the male died after becoming entangled in a barbed wire fence on his territory. Again, the female was recaptured and returned to PWRC.

The experiment was repeated in 1989, but earlier in the season (May) than the 1981 and 1982 attempts (June). A captive six-year-old female from PWRC was placed in a pen on a wild male's territory at GL. The male exhibited much interest in the female and after 1 week she was released from the pen. Considerable pair formation behavior occurred between the two birds including unison calling and copulations. No nesting attempt was made, perhaps because it was somewhat late in the season. The male molted his flight feathers and secluded himself in the marsh. In early June the female abandoned the flightless male but was joined by another wild male.

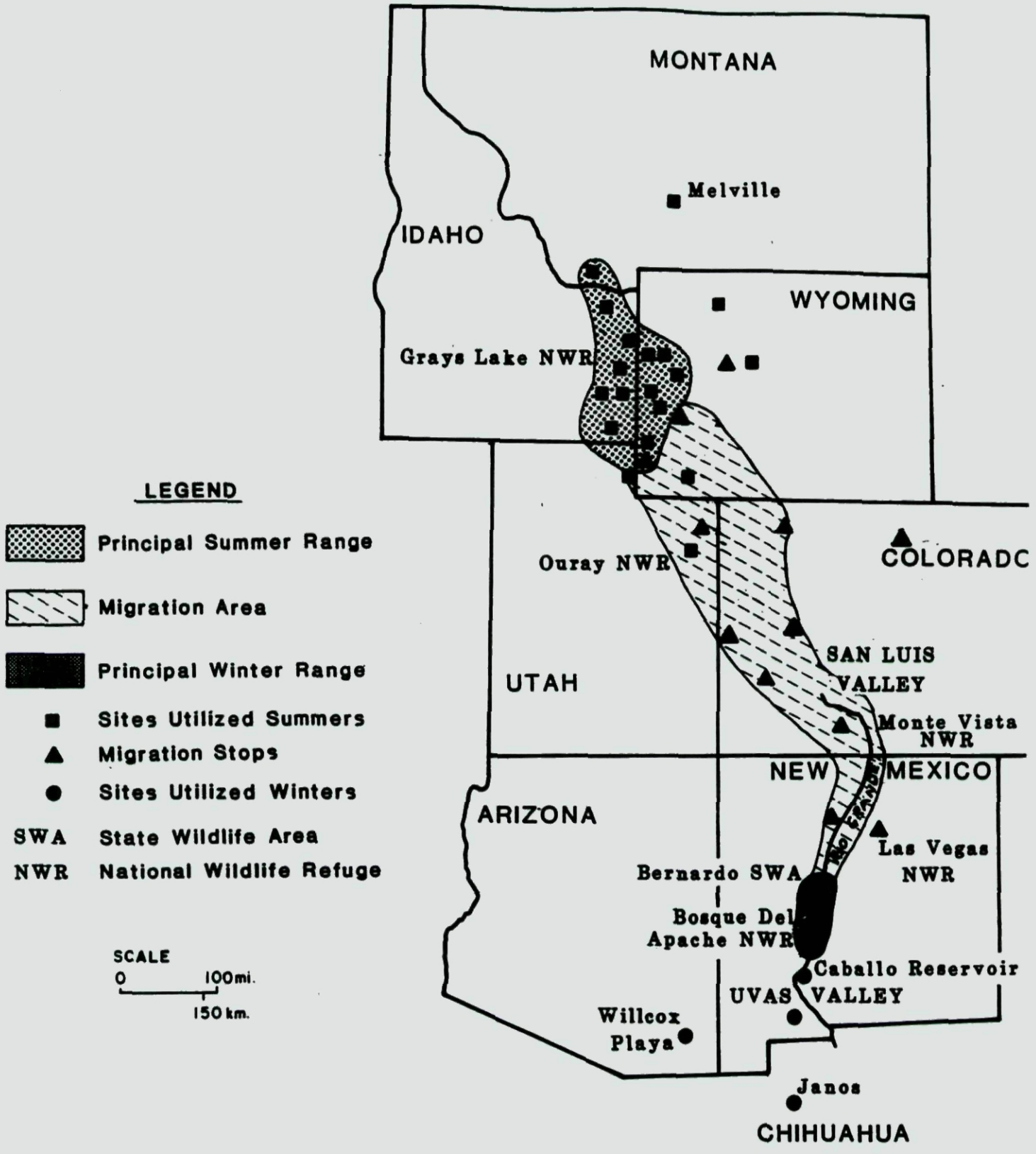

Figure 4. Summer and winter ranges and migration route of the RMP.

Table 7. Eggs transplanted, hatched, and chicks fledged at GL, Idaho, 1975-1988.

Year	Origin Of Eggs	No. Eggs Transplanted	No. Eggs Hatched	No. Chicks Fledged
1975	Canada	14[a]	9	5
1976	Canada	15[b]	11	4
	PWRC	2	0	0
1977	Canada	16	15	4
	PWRC	14[c]	5	0
1978	Canada	13	9	3
	PWRC	15[d]	5	0
1979	Canada	19	12	6
	PWRC[e]	5	4	2
1980	Canada	13	10	4
	PWRC	2	2	1
1981	Canada	12	5	0
1982	Canada	14	8	3
	PWRC	13	11	4
1983	Canada	16[f]	15	11
	PWRC	12[f]	11	8
1984	Canada	22[g]	19	10
	PWRC	10[f]	6	2
1985	Canada	23h	20	11
1986	Canada	15i	11	2
1987	Canada	12	12	2
1988	Canada	12	10	2
Subtotal	Canada	216	166	67
	PWRC	73	44	17
Total		289	210	84

a Two of 14 eggs lost to predators.
b Four of 15 eggs lost to predators.
c Three eggs deserted after a snowstorm, one egg lost to a predator.
d Examination of 10 eggs that did not hatch revealed that 4 were infertile, 2 contained early-dead embryos, and 4 contained late-dead embryos.
e Poor hatchability of PWRC eggs-during the period 1976-1978 was due largely to egg infertility (11 eggs) and artificial incubation (20 eggs). After 1978, only eggs containing viable embryos (as determined by flotation) were transferred and all eggs were incubated under sandhill cranes at PWRC before their transfer.
f One egg lost to a predator before hatching.
g Three eggs lost to predators before hatching.
h Three eggs believed to be infertile or to contain early dead embryos at the time of transfer.
i Two eggs were eaten by predators and two failed to hatch.

The new pair remained together for over four months. Between 5 - 15 October, the male was observed initiating migratory flights on five occasions with the female following. However, the female was unable to keep up with the male and she always returned to the territory with the male following. On October 15 the male migrated alone. The only other whooper present, a wild male, immediately joined the female for 2 days until he migrated.

The female's history of six years in captivity apparently rendered her physically incapable of sustaining long flights. Attempts to capture her in late October were unsuccessful and she disappeared. The behavior of the males at GL demonstrated that they were highly responsive to the presence of a female during the breeding season. Observations indicated that a long-term pair bond would probably have occurred had the female been able to fly properly and completed the migration.

During the 1980's it became apparent that older females did not return to GL or other areas occupied by territorial males during the summer. Experiments to enhance pair formation were carried out from 1986 through 1990 whereby 20 whooping cranes (some individuals were recaptured several times) were captured in isolated summer sites and released at GL near male whooping cranes (Drewien and Clegg 1992). Five (2 males, 3 females) were held for one to four months in a pen prior to being released. Objectives of the experiment was to enhance pair formation opportunities. Although these translocation experiments contributed to numerous associations and interactions between individuals of both sexes, no permanent pair bonds developed. The longest associations lasted two to four months before males and females separated. These results suggested that imprinting problems possibly existed in whooping cranes raised by sandhill cranes. The females exhibited only minimal responses to the presence of males.

From 1975 through 1988, 289 eggs were transferred (including 73 eggs from the captive flock at the PWRC), 210 hatched, and 85 chicks fledged (Drewien et al. 1989, Ellis et al. 1992). The RMP peaked at 33 birds in 1985 and has declined since then to 10 birds. Dr. Edward O. Garton, biometrician at the University of Idaho, working with Dr. Rod Drewien the leader of the cross-fostering project (Garton et al. 1989), modelled the cross-fostered population to predict when it might become self-sustaining. In the model they assumed (1)

The cross-fostered females would be breeding at the same rate as the females in Canada; and (2) survival of birds in their first year would be similar to that of first year birds in Canada (Garton et al. 1989). Despite these optimistic and unrealized assumptions, with the future transfer of 30 eggs per year, the population would only reach 6 breeding pairs after 50 years. "It is obvious from all scenarios modelled that egg transplants of less than 30 eggs per year will not suffice to establish a self-sustaining population in a reasonable period of time. Natural breeding will be essential to establish a self-sustaining population" (Garton et al. 1989). The lack of pairing and reproduction, prolonged drought on the summer area, and the high mortality led to discontinuing the egg transfers in 1989.

Sexual imprinting of a foster-reared species on the foster-parent species had already been confirmed in foster-reared raptors, waterfowl, gulls, finches, and gallinaceous birds (Bird et al. 1985, Immelmann 1972). One test of the imprinting problem occurred at ICF where sandhill cranes were foster-reared by red-crowned cranes (sample of one), white-naped cranes (sample of 2), and Siberian cranes (sample of one). When given a choice the cross-fostered sandhill cranes socialized more with the foster species than with conspecifics. The two foster-reared females showed a stronger preference for the foster species than did the two foster-reared males (Mahan and Simmers 1992). By the fall of 1992, cross-fostered adult female whooping cranes of ages 4 through 12 years had passed through a nesting season on 34 occasions without pairing. Whooping cranes at WBNP begin egg production at an average age of 4 years (E. Kuyt, pers. comm., 1991).

In 1992, a wild cross-fostered male whooping crane paired with a female sandhill crane to produce a hybrid chick. Four hybrids were previously produced by artificial insemination in captivity at Patuxent. The hybrid wild chick provided additional evidence that cross-fostering may break down behavioral barriers that normally discourage pairing between the two species.

K. Reintroduction Studies In The East

A November 21, 1975, letter to members of the Whooping Crane Recovery Team from the Florida Game and Fresh Water Fish Commission (Commission), suggested the possibility of reestablishing a non-migratory whooping crane population in the eastern United States. No *genetically pure representative of the nonmigratory Louisiana flock remained in captivity.* The letter proposed that Florida sandhill cranes might be used as surrogate parents to instill non-migratory behavior into cross-foster whooping cranes with the goal of restoring a non-migratory flock in the Southeast. It should first be determined that migratory sandhill cranes reared by Florida sandhill crane foster parents would be non-migratory.

In 1977, John Allender (Audubon Park Zoological Garden) and George Archibald submitted a proposal to reintroduce whooping cranes to Louisiana. The proposal was tabled for several reasons. The Service did not wish to endorse other reintroduction efforts until the cross - fostering project was fully evaluated (letter of Lynn Greenwalt, Director, FWS to Regional Directors, May 1978). Wildlife agency personnel were also concerned that critical habitat might be designated within the State as a consequence of a release, a designation which might lead to unfavorable constraints on land and hunting management (March 1978 letter of J. Burton Angelle, Secretary, Louisiana Wild Life and Fisheries Commission, to George Archibald). Resource agency personnel in Louisiana were concerned that restrictions on

hunting of geese and ducks might be imposed as a consequence of the presence of an endangered species (Gomez 1992). Federal concerns included the belief that local residents might not be instilled with a conservation ethic sufficient to permit success of the reintroduction (letter from D. L. Hall, Special Agent In Charge, U.S. Fish and Wildlife Service, April, 1978).

In 1979, the recovery team contacted the Florida Commission to ask if there was interest in evaluating the feasibility of establishing a non-migratory flock of whooping cranes in the Southeast. Research to address the question began in 1980. One member of each of several established pairs of Florida sandhill cranes was captured and instrumented with a radio transmitter. When nesting began, eggs of greater sandhill cranes, obtained from Patuxent or from the wild in Wisconsin or Idaho, were substituted for the pair's natural clutch. Hatching and rearing of the young were monitored until the resultant chick/chicks were 55 to 60 days old. The young were then captured, radio tagged, and plastic leg bands attached. Movements were monitored through one or two spring migrations following separation from their parents.

By the mid-1980's, questions began to arise concerning the lack of pairing behavior of whooping cranes cross-fostered by sandhill cranes. It was necessary to test an alternative reintroduction technique and in 1986, releases of captive-reared sandhill cranes began. Four cohorts of captive-reared greater sandhill cranes were soft- or gentle-released in Florida during late winter or early spring (Nesbitt and Carpenter 1993). Concurrently a group of Florida sandhill cranes (1- or 2-year-olds) from known natal sites were captured, radio-instrumented, and monitored as a control to compare with dispersal among the experimental groups.

Thirty-four greater sandhill crane eggs were transferred into 23 Florida sandhill crane nests between 1982 and 1987. From these transfers five young were produced which survived to the age at which they separated from their parents. Twenty-seven captive-reared young were released (4 cohorts) during 2 years (15:4 April 1986; 12:2 January 1987). They were all radio-instrumented and distinctly color banded. Eighteen survived through at least one complete spring migration and two fall migrations. Only southerly movements by some individuals (60 to 120 km) exceeded normal dispersal of subadult Florida sandhill cranes. In the one instance of the 120 km movement south the birds returned within 6 weeks to the general vicinity of release. The movements of the dispersing experimental birds did not differ significantly (P greater than 0.05), either in direction or timing (date) of movement from that of a control group (Nesbitt and Carpenter 1993).

In 1983, the U.S. Recovery Team met to select sites to evaluate for a third wild population. Eastern sites were proposed because they would be discrete from the wild populations in central and western United States. Sites selected were Seney NWR and adjacent areas in the Upper Peninsula of Michigan and Ontario, Okefenokee Swamp in southern Georgia, and three sites in Florida (Lewis and Cooch 1992). Three-year research projects were established in each of the three principal areas. Research began in October of 1984.

Although the development of reliable methods for reintroducing captive-produced cranes to the wild has proven to be a relatively difficult task, considerable progress has been made in the past decade. A number of experimental soft or gentle releases have already been

conducted with captive-reared sandhill cranes (Nesbitt 1979, Drewien et al. 1981, Zwank and Derrickson 1981, Bizeau et al. 1987, Leach 1987, Zwank and Wilson 1987, Nesbitt 1988, Ellis et al. 1992, Urbanek and Bookhout 1992, Archibald and Archibald 1992, Horwich et al. 1992, Nesbitt and Carpenter 1993), and additional releases are currently underway or are being planned in order to refine reintroduction techniques for whooping cranes. Soft or gentle releases involve the gradual transition from life in captivity to free-ranging wild life. This involves the use of large fenced enclosures in which food and water are provided and from which potential predators are excluded. The cranes are placed in the enclosures and their wings brailed to prevent flight. After an appropriate acclimation period the brailes are removed and the cranes can fly from the pen whenever they wish.

The final reports on the eastern study sites were submitted in the winter of 1987-88 (Bennett and Bennett 1987, Bishop 1988, Nesbitt 1988, McMillen 1987). In the summer of 1988, the recovery team recommended that the next reintroduction should be an effort to establish a non-migratory population in the Kissimmee Prairie of Florida. The primary reason the Team chose to endeavor to establish a non-migratory population instead of a migratory population, was the failure of the cross-fostering technique in Idaho and the lack of any tested technique to establish a migratory population.

Nonmigratory sandhill and whooping cranes occurred together in Louisiana (McIlhenny 1943). Florida's population of non-migratory sandhill cranes is estimated to be between 4,000 and 6,000 individuals, with 8 percent to 16 percent juveniles in the annual population. Florida has only a small number of wintering snow geese and no goose or crane hunting, so hunting conflicts are unlikely. Florida, therefore, appears to be an appropriate place to attempt to establish a nonmigratory flock of whooping cranes.

Bishop (1988) recommended Three Lakes Wildlife Management Area (WMA) as the preferred release site. The Kissimmee Prairie consists of approximately 2,000 square kilometers of flat, open palmetto prairie interspersed with shallow wetlands and lakes. On private ranch lands, much of the prairie has been converted to improved pasture. Land ownership includes 8 large ranches totaling 82,200 hectares. Large private holdings range from 2,700 ha to 42,500 ha. Public lands range 2,955 ha to 43,300 ha and include Three Lakes WMA, the National Audubon Society's Ordway-Whittell Kissimmee Prairie Sanctuary (2,955 ha), Kicco WMA (3,100 ha), Bull Creek WMA (8,425 ha), Upper St. John's River WMA (24,800 ha), and Avon Park Bombing Range (43,300 ha). The Three Lakes WMA had been identified as the preferred site within Florida (Bishop 1988). The best crane habitat on the 22,450 ha WMA lies between lakes Jackson and Kissimmee.

The Canadian Recovery Team endorsed the Kissimmee Prairie site in fall 1988. The Director of U.S. Fish and Wildlife Service and the Director General of Canadian Wildlife Service approved the project early in 1989. Four or five possible sites to construct release pens were identified during summer 1990. During 1991 a 50 X 130 m release pen was built on the edge of Lake Jackson the most accessible of the lake sites. Construction of a second pen (50 X 100m) located 200m from Lake Marian, was completed late in 1992. Additional pens may be built in the future, though none closer than 5 km from another. The release pen conforms to what has been successfully used in releases of cranes at the Mississippi Sandhill Crane NWR.

In January 1993, the first group of 14 whooping cranes was released in Kissimmee Prairie, Florida (Fig. 5). This release was a soft-release managed similarly to previous sandhill crane releases in Mississippi and Florida (Ellis et al. 1992). This population was designated experimental nonessential to increase flexibility of management (Lewis and Finger 1993). The objective of this first release is to evaluate the response of the cranes to the Florida habitat and evaluate release techniques. Five parent-reared birds were released in December of 1993 and 14 isolation-reared birds are expected to be released in February 1994. At regular intervals the released birds will be recaptured and samples taken to evaluate exposure to disease, and parasites. If the results of these initial releases are favorable, releases of 20 or more individuals will occur annually for up to a decade or longer beginning in fall-winter of 1994/1995.

Releases of isolation-reared cranes have resulted in high post-release survival both in migratory as well as nonmigratory situations (Horwich 1986, 1989, Archibald and Archibald 1992, Ellis at el. 1992, Horwich et al. 1992, Urbanek and Bookhout 1992). These experiments included work at ICF, Seney National Wildlife Refuge, and by PWRC in Mississippi. Research on the Upper Peninsula of Michigan as a potential reintroduction site for whooping cranes (McMillen 1987) led to a study of the isolation-rearing, gentle release method for reintroducing migratory cranes (Urbanek and Bookhout 1992) in 1988-1990. Thirty-eight fledged greater sandhill crane chicks were released to the wild after being isolation-reared and exposed to natural conditions accompanied by a caretaker in a bird-like costume. (Isolation-rearing refers to rearing the birds separated from visual contact with humans). They were reared at the release site. Wild resident sandhill cranes were baited to a release enclosure where they associated with the captive-reared birds. If the two groups were in association at time of migration, the captive-produced birds accompanied the wild birds and learned the proper migration route and wintering site. Minimum survival 1 year after release was 84 percent, and the minimum return rate to Upper Michigan was 74 percent. The authors noted the need for similar studies on captive-reared whooping cranes to see if they will associate with and learn migration from resident wild sandhill cranes (Urbanek and Bookhout 1992). These studies should occur whenever sufficient funds and whooping crane eggs are available without detracting from other ongoing reintroduction studies. The study site should be part of an approved reintroduction location.

L. Research on Reintroduction Techniques For Migratory Populations

There is no proven technique for reintroducing whooping cranes into a migratory situation. Such a technique must be identified if recovery goals for downlisting are to be accomplished. Several techniques deserve testing and include the following:

1. Release of captive-reared whooping cranes into the nesting or staging areas of wild sandhill cranes with the hope the whooping cranes will learn survival techniques and migration patterns from the sandhills;

2. Training captive-reared whooping cranes to follow in flight a truck or an ultra-light aircraft. Use this following behavior to teach the birds an appropriate migration route, stopover sites, and wintering locations, and;

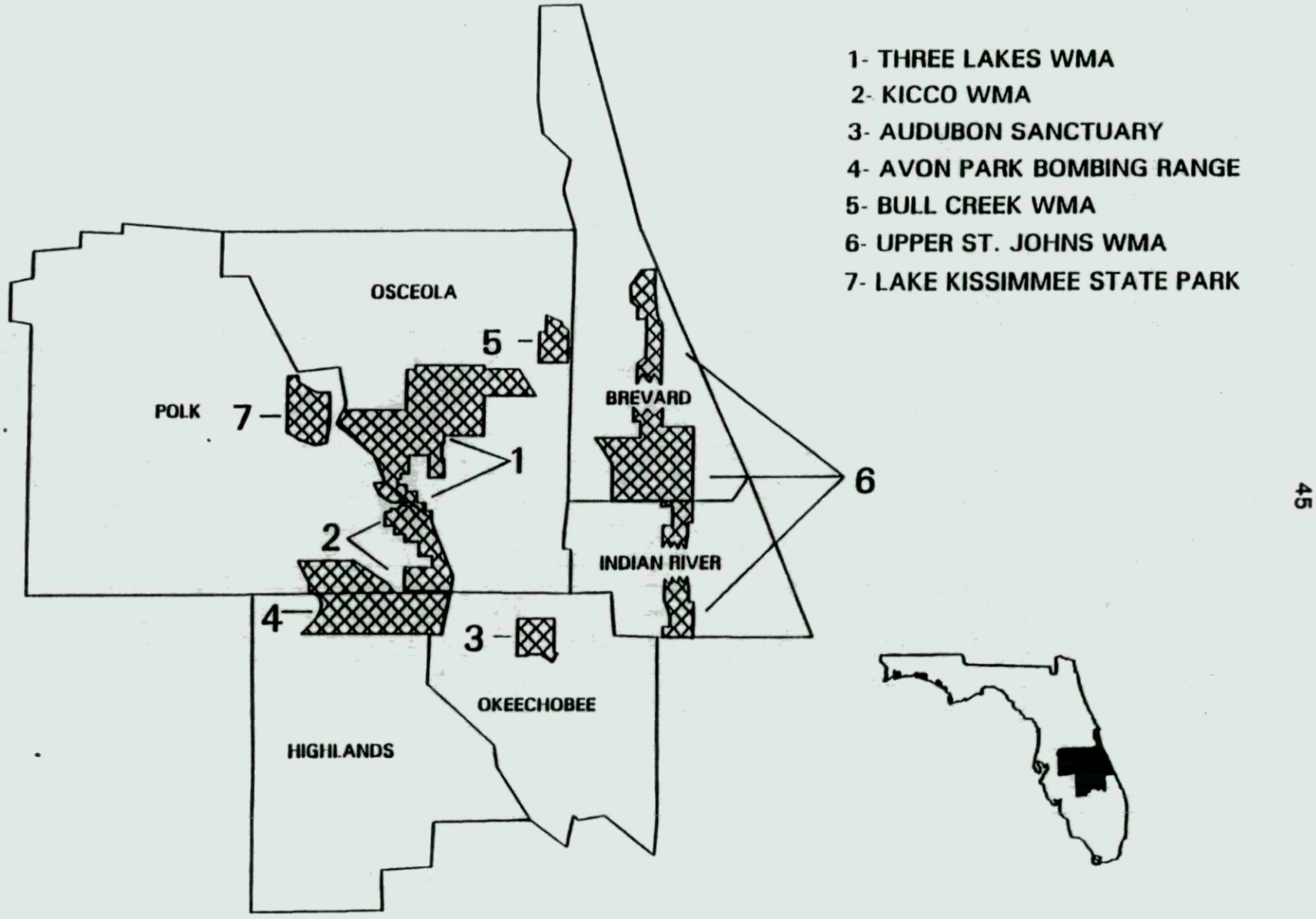

Figure 5. The Kissimmee Prairie, Florida, release area and key land management units.

3. Promoting adoption of captive-reared whooping crane chicks by wild adults established in an area through cross-fostering to sandhill cranes. The adoption process would add to the wild population a group of whooping cranes without the improper imprinting problems. The young birds, hopefully, will learn migratory and survival techniques from their adoptive parents. This approach has been termed the guide bird technique.

The Grays Lake cross-fostering experiment successfully produced wild whooping cranes capable of migrating and surviving in a challenging environment. However, because these cranes did not pair, and have experienced excessively high mortality, a technique for reestablishing a self-sustaining migratory population is lacking. A potential solution would be to use cross-fostered whooping cranes as guide birds to introduce young captive-produced whooping crane chicks into the wild. Members of the Canadian Whooping Crane Recovery Team in 1992 suggested the guide bird experiment as an appropriate use of the birds surviving in the RMP. Such an experiment would test one technique which might be used to establish another migratory population in Canada late this century. The young whoopers, reared by adults of their own species, might learn to survive in the wild and follow a predetermined migration route in the Rocky Mountains. Being reared by conspecifics, they would be sexually imprinted on their own species.

Ten adult whooping cranes survive in the RMP, including 4 females. Males range in age from 8 to 16 years and females from 8 to 12 years. Six of these whooping cranes winter annually at Bosque del Apache NWR and 2 at state game management areas north of the refuge. Three captive-reared chicks were released into the population in the guide bird experiment in fall 1993 and one survived in the winter of 1993-1994 in New Mexico.

The cross-fostered cranes have exhibited various parental behaviors on summer territories at GL and in a pen nearby. Solitary territorial males have helped neighboring sandhill crane pairs raise young, including protecting, feeding and brooding them. Several males have built nests. One male intermittently incubated an empty nest and a sandhill crane egg placed in this nest. In 1988, 2 male whoopers assisted a sandhill crane foster-parent pair raise a whooping crane chick. Male and female whoopers associated with, fed and temporarily reared sandhill crane chicks in the pen during 1990-91. These activities and chick adoptions at the United States captive facilities, suggest that some cross-fostered whooping cranes might adopt or bond with and rear a whooping crane chick. Such bonding experiments will occur in pens with wild-captured adults and on the spring territory of free-living wild birds. These experiments began in 1993 and will continue in 1994. Four to six whooping crane chicks are planned for use in this research each year. The completion of the 2-year project will provide another decision point about future efforts in the Rocky Mountains, and an opportunity for review and recommendations by all interested parties. The other techniques for reintroducing a migratory population should be tested in the Rocky Mountains or at other geographic locations.

As part of the guide bird experiment, the Service is proposing to designate the RMP as experimental nonessential. The "experimental" designation increases the flexibility of the Service and other land management agencies to manage reintroduced populations because they can be treated as threatened species rather than endangered. The Service has more discretion in devising management programs for threatened species than for endangered

species, especially on matters regarding incidental or regulated takings. The Act amendment also allowed designation of a population as "nonessential" to the continued existence of the species in the wild. Populations designated nonessential are to be treated as if they were only proposed for listing for purposes of section 7 of the Act, except on national parks and national wildlife refuges. Designation of the RMP as experimental nonessential would mean greater management flexibility, the potential for regulated takings, and the population would no longer be subject to the formal consultation requirement of section 7 of the Act except on refuges and national parks.

The Endangered Species Act states that critical habitat shall not be designated for experimental populations. Critical habitat was designated for whooping cranes in the Rocky Mountains in 1978 and covers three refuges (Bosque del Apache, New Mexico; Grays Lake, Idaho; and the Alamosa/Monte Vista complex, Colorado) plus a 1 mile buffer of private land around GL. The buffer around GL is rangeland and a few small farms raising wheat and grazing cattle on improved pasture. There are no activities on these private lands which represent a hazard to whooping cranes. If the designation of the RMP cranes is changed to experimental nonessential, it will be necessary to rescind the critical habitat designations. However, because the critical habitat is almost entirely in Federal ownership, and section 7 of the Endangered Species Act still applies for actions on national refuges occupied by experimental populations, protection of the habitat will not be significantly diminished.

M. Population Viability Analysis

The Population Viability Assessment Workshop for the whooping crane was funded by the Service. It was a collaborative endeavor, with Canadian Wildlife Service, The United States and Canadian Whooping Crane Recovery Teams, the International Crane Foundation, and the Captive Breeding Specialist Group, Species Survival Commission of International Union for Conservation of Nature. The final report includes priorities for research and management of the wild and captive populations as a meta-population to maximize retention of genetic heterozygosity and minimize the risk of extinction (Mirande et al. 1993).

Based on the population size in the bottleneck of 1941, the current population is derived from an estimated 6 or 8 founders. In the first generation that would have resulted in a loss of 6% to 8% of gene diversity. (The generation time is assumed to be about 12 years). Estimates are that about 87% of the gene diversity has persisted since 1938. About 96% of the gene diversity present in the wild flock has been retained in the captive-hatched descendants.

Modelling showed annual population growth to be 0.046 (SD=0.081) over the last 50 years. If this rate continues, the population will reach 500 birds in 27 years (about 2020) and 1,000 in 42 years (2035). The standard deviation is about double the mean growth rate so in many years the population will decline temporarily even though long-term growth may be good. The population is projected to have a very low probability of extinction over the next 100 years (less than one percent). The whooping crane has the highest long-term recruitment rate (13.9 percent) of any North American crane population (Drewien et al. 1993).

Modelling the captive population since its establishment indicates a growth rate of only 1.1% through 1991 (SD-0.114). At that rate the population would only be 127 birds at the end of 100 years and only 89% of the initial heterozygosity would be retained. However, the group noted that improvements should be achievable over the next 1 to 5 years. In fact, major improvements in production occurred in 1992 and 1993, indicating that the captive flocks will be able to sustain a reintroduction program if these improved production levels continue.

PART II RECOVERY

A. Objective and Criteria: To downlist the whooping crane from endangered to threatened status by increasing the wild population to 90 nesting pairs in three separate populations by 2020.

Part I described the biology of whooping cranes, the factors that lead to endangerment, and research and management progress to date. Throughout the discussions the Recovery Team has briefly referred to information needs and plans for the future. Although the progress to date has been substantial, much still must be done before the whooping crane can be downlisted from Endangered to Threatened status. The actions proposed in this Plan will, with high probability, result in sufficient improvement in the status of whooping crane populations so that official listing can be changed from Endangered to Threatened. Based on the past history of this species, the low reproductive rate, and threats to habitat required for breeding, migration, and wintering, the whooping crane may never be an abundant species. Preservation of this species will require the interest and concern of an informed public. The present numerical goals for downlisting are best estimates of the numbers for population viability and may need to be modified in the future as additional information becomes available.

The first recovery goal for the whooping crane is a change in status from Endangered to Threatened. Based on existing knowledge, the minimum requirements for downlisting are maintenance of the AWP above the current 40 nesting pairs and the establishment of at least two additional, separate and self-sustaining populations, each consisting of 25 nesting pairs. The Service proposes to promote growth of the AWP to 1,000 individuals, a level that is likely to allow survival as a population despite any future catastrophic event. These populations may be migratory or nonmigratory. These goals should be attained for 10 consecutive years before the species is reclassified to Threatened. That goal is unlikely to be reached before year 2020. A goal for delisting the species will be set prior to downlisting sometime in the 21st Century.

By identifying three self-sustaining wild populations as a requirement for downlisting, the Service recognizes the need for multiple populations for protection against stochastic, catastrophic events in nature. At their 1988 meeting, the recovery team concluded there was no minimum number of birds considered sufficient in the wild as long as there is only one population. Therefore, the Service believes a single wild population remains vulnerable to extinction during one, or a series, of adverse events, regardless of the size of the single population. A single large population cannot substitute for the greater security provided by multiple, discrete populations.

To attain reintroduction goals, it is proposed that about 40 captive breeding pairs of whooping cranes be in place by year 2000. The 40 breeding pairs will be comprised of 15 pairs at PWRC, 15 at International Crane Foundation, and 10 at Calgary Zoo. Production from ICF and Patuxent will be the principal source of release birds in the Florida reintroduction effort for the balance of this decade, if that reintroduction seems promising and is continued after the first 2 years of the experiment. However, sources of release birds should be based on the optimal genetic mix to ensure long-term viability of the population.

The Calgary Zoo facility likely will be producing young by 1996, and along with chicks reared from eggs from the AWP, should be able to start a second migratory population in Canada late this decade (see Canadian Recovery Plan). The first priorities for use of captive-reared chicks in the next few years are for completion of stocking the Calgary Zoo facility and continuing releases in Florida. Calgary Zoo should be fully stocked by the close of 1994. Chicks from AWP wild-collected eggs will be available for use in guide bird experiments in 1993 and 1994. The Service anticipates research continuing through the 1990's on methods of introducing whooping cranes in a migratory situation. Further experimentation with the RMP will depend upon the results of the first two years of guide bird research, approval by the principal involved parties, and availability of funds and whooping cranes surplus to higher priority recovery needs. If the reintroduction in Florida is successful, other nonmigratory populations might be considered for the 21st Century.

As noted previously, this Plan describes only the recovery actions and costs required for birds and habitat within the United States. Recovery actions to be taken in Canada are described in the Canadian Whooping Crane Recovery Plan. It is the goal of the United States recovery team that the second migratory population in Canada be discrete from the existing migratory population so they will not winter, nest, or migrate through the same areas. The CWS in 1993 began identifying historical whooping crane nesting habitat in southern Canada which might provide suitable reintroduction sites. CWS proposes to begin in 1994 radio telemetry studies of sandhill migration pathways which will help identify the migration pathways which might be taken by whooping cranes reintroduced in the potential reintroduction sites.

B. Narrative Outline For Recovery Actions Addressing Threats

1. Increase the AWP.

This task is directed at reducing mortality during migration and at wintering areas and removing habitat constraints which might limit population recovery. The present winter habitat has the potential to support substantially more than 40 nesting pairs and the associated subadults and young-of-the-year (pers. comm., T. Stehn). As the population increases, the threat of extirpation due to some natural stochastic event (hurricane, disease epizootic, contaminant spill) diminishes, thereby increasing species security. Annual aerial population census on the wintering area will be required as a part of management of this population.

11. Monitor movements.

The spring and fall migration monitoring coordinated by Region 6 of the U.S. Fish and Wildlife Service should be continued. This project, headquartered at Grand Island, Nebraska, coordinates and records sighting data pertinent to identifying migration stopover habitat and reducing mortality from disease and shooting. Of particular importance is the analysis of sightings of marked cranes and identification of traditional migration use areas.

12. Reduce mortality.

A number of whooping cranes disappear during most years and the causative factors are not fully known. Identifying causes of loss and applying remedial management are important objectives. Develop methods to address mortality factors not considered in subtasks below. Initiate research to measure impacts of newly detected mortality factors and develop methods to minimize their impacts.

121. Prevent shooting.

Three AWP whooping cranes have been shot during migration or on wintering grounds in the last five years. Other unexplained losses may be due to shooting. Substantial hunting of sandhill cranes and snow geese occurs in and adjacent to areas used by migrating and wintering whooping cranes. Sandhill cranes and snow geese are somewhat similar in appearance to whooping cranes and whooping cranes may be misidentified and shot by some novice hunter. State and Federal wildlife agencies follow the Contingency Plan for Cooperative Federal-State Protection of Whooping Cranes when whooping cranes occur in hunt areas. Education programs should continue to increase competency of the public to identify whooping cranes, and to make them aware of the species rarity and protected status.

122. Diminish disease losses.

Loss of wetlands has concentrated birds using aquatic habitat, thereby increasing the risk of disease. For example, avian cholera epizootics occur fairly regularly in several crane use areas and this disease has been recorded in one whooping crane. Methods of disease prevention, detection, and treatment need to be developed. Of particular concern are avian tuberculosis, encephalitis, and crane herpes. Every precaution should be taken to prevent whooping crane use of areas where waterfowl disease outbreaks are underway or recently occurred. The Contingency Plan for State-Federal Cooperative Protection of Whooping Cranes covers response to disease incidents. Disease response efforts will be directed by the National Wildlife Health Research Center. The outcome of disease research will determine where prevention and control methods should be directed, as well as, whether control will involve site modification, interspecific separation of use, or individual prophylaxis (or a combination thereof).

123. Minimize chemical spills.

Numerous oil and gas wells and connecting pipelines are located in bay and upland sites near the cranes' winter habitat. Many barges carrying dangerous chemicals travel the Gulf Intracoastal Waterway daily through the heart of whooping crane winter habitat. A spill or leak of these substances could contaminate or kill the cranes' food supply, or poison the cranes (Robertson et al. 1993). The Fish and Wildlife Service should coordinate, with the appropriate regulatory agencies, all aspects of the oil and gas industry as it relates to whooping crane habitat. Responsible agencies should be actively encouraged to inspect facilities to see that

they conform to regulations and, if needed, to modify regulations to provide protection for cranes. The U.S. Army Corps of Engineers is evaluating the merits of rerouting a portion of the waterway outside of the area of concentrated whooping crane use to reduce the danger of chemical and petroleum spills and leaks from boats and barges. Quivira NWR is an important stopover site for migrating whooping cranes. The refuge contains numerous oil and gas wells where spills could occur. However, each site is surrounded by a containment berm to ensure site protection if a line ruptures.

124. Diminish collisions.

Collisions with powerline and fences are a frequent known cause of death or injury of whooping cranes. New lines should be routed around areas frequently used by whooping cranes, and existing problem lines or fences should be marked to reduce collision. Unnecessary fences should be removed from crane use areas on national wildlife refuges and barbed wire fences should be of no more than 3-strand design. Efforts should be made to maximize visibility of any existing structures or those which of necessity must be constructed in whooping crane use areas or flight routes.

13. Restrict detrimental human activities.

Human disturbance of whooping cranes is chronic and results from activities such as petroleum exploration, mining, hunting, fishing, bird watching, and boat and airplane traffic. Some disturbances cause the birds to leave an area; the effects of others may be more subtle. Sources and intensity of disturbance are expected to increase in the future. The cumulative effect on cranes should be evaluated.

131. Restrict construction periods.

Seismic exploration, drilling, pipeline activity, dredging, and other development or construction activities within or near whooping crane critical habitat should be conducted only when cranes are absent. This scheduling should be accomplished through Federal and State permitting procedures and by agreement with the company or agency involved.

132. Restrict aircraft altitude.

An altitude restriction of 2,000 feet minimum, required by Federal Aviation Administration regulations, is particularly important in regulating helicopter flights. Biological survey flights and emergency situations, including unusual weather conditions, should be the only exceptions to these restrictions.

133. Restrict other detrimental human activities.

The public has access to much of the whooping crane wintering habitat because most water areas are public. Whooping cranes are somewhat tolerant of human presence when people are in carefully operated boats. Airboats, cars and trucks

may be more disturbing, and cranes are particularly sensitive to humans on foot. Crane displacement results in short-term or long-term loss of habitat and social disruption of the flock. Unnecessary human activities should be prohibited or regulated wherever they cause problems for the cranes.

14. Identify, protect, manage, and create habitat.

Protecting and enhancing whooping crane habitat is a major concern due to increasing demands being placed upon such habitat. The historically-used area along the Texas coast, including the Aransas NWR and Matagorda Island, is essential to the needs of the whooping crane, and has been declared critical habitat under the Endangered Species Act. Several areas on the migration route have been identified as essential or critical habitat. Although radio tracking migrating cranes and an analysis of sighting data indicate that some areas may receive periodic use, additional efforts are needed to identify areas which are consistently used, and to determine why these areas are selected by whooping cranes. Important migration stopover areas should be protected.

141. Identify essential habitat.

Suitable stopover habitat is necessary for the birds to complete their migration in good condition. There has been considerable alteration and destruction of natural wetlands, rivers, and streams, some of which have served as potential roosting and feeding sites for migrating cranes. There may be areas along the migration route that need to be delineated and protected. Additional study is needed to delineate areas that are important to migrating whooping cranes. The unique characteristics of such habitat should be identified and described. Solicit reports and sightings of whooping cranes. Sightings should be verified by qualified observers. Records should be cataloged and stored in computer data banks in Region 6 of the Fish and Wildlife Service. Identify food and water requirements of an expanding crane population in the winter habitat. Spatial needs of all wintering crane groupings (adult pairs, family groups, subadult groups) must be investigated to understand behavioral factors that influence habitat use. Identify nutritive requirements of the cranes and the nutritional composition of their principal winter foods. The biomass of the food base should be documented.

142. Protect habitat.

Various measures are needed to ensure long-term protection of migration stopover and wintering habitat required to accommodate an expanding population. Whooping cranes make extensive use of wintering habitat on lands without Federal or State refuge protection. Much of this land is in private ownership. The threat of increasing human activity and development, which would be detrimental to the cranes and their habitat, makes it highly desirable to protect these areas. In most instances, this action would not significantly alter current uses. Where non-refuge lands are involved, work with owners/managers to ensure that habitat remains suitable for cranes. In some situations it may be necessary to lease or purchase a site to preserve its value for whooping cranes.

1421. Prevent contamination of habitat.

Preventive measures range from efforts to minimize existing damage to the long-range efforts to reduce the potential for contamination of habitat. Whooping crane protection should be specified explicitly in contaminant spill contingency plans which involve State and Federal agencies along with local oil spill control groups in efforts to contain and clean up leaks and spills which could impact whooping crane habitat. An oil spill contingency plan was completed for Aransas National Wildlife Refuge in April 1993 (Robertson et al. 1993). Response to contaminant spills of all types along the Texas coast is primarily the responsibility of the U.S. Coast Guard.

1422. Prevent erosion of habitat.

Wakes from sport and commercial boats erode critical whooping crane habitat along the Gulf Intercostal Waterway. Ponds and sloughs in the marsh are drained as erosion breaches their margins. Reduction of boat speeds, armoring banks, reducing breakwaters, and relocating a segment of the GIWW are options for reducing erosion.

1423. Regulate deposition of dredge spoil.

Dredging of channels and slips, and disposal of dredge spoil can cause serious damage to whooping crane habitat. Permit applications for such projects should be reviewed carefully and rejected if they are incompatible with whooping crane management objectives. Solutions include reuse of existing disposal sites by removal of dredged material after it drys, barging or pumping of sludge material to sites away from the marsh, and relocation of a segment of the GIWW. Experiments to create new crane marshland and breakwaters with dredged materials should be continued.

1424. Maintain freshwater inflows.

Freshwater inflow from hundreds of miles inland are essential to maintain the productivity of coastal waters used by the cranes. Inflows provide nutrients and buffer salinity levels so they remain favorable for production of food needed by whooping cranes. Salinity levels which allow whooping cranes to drink coastal waters rather than fly inland to drink are maintained. Upstream reservoir construction and water diversions for agriculture and human use reduce these inflows. Consultations on such flow modifications must continue to ensure that downstream water needs are met.

143. Manage habitat.

First priority should be given to habitats designated as critical or essential. Management practices on national wildlife refuges, Federal waterfowl production areas, and State wildlife areas that have been utilized by whooping cranes, or have potential for their use, need to be re-examined for the potential of developing and

maintaining habitat important to whooping cranes. Habitat management on private lands needs to be accomplished through acquisition or cooperative agreements. Adequate assessment of management practices requires that certain predetermined measurements be taken to monitor accomplishments versus desired results. Additional, unplanned results may occur and monitoring must be sufficient to detect and measure those effects as well as to avoid potentially detrimental impacts on the cranes or their habitat.

1431. Maintain upland water sources.

About 20 freshwater ponds are present on Aransas NWR in areas used by cranes. Cranes drink at upland freshwater ponds where surrounding vegetation is kept low to the ground and aquatic emergent or floating vegetation is sparse or absent. Such ponds provide a source of fresh water when coastal waters are highly saline and may encourage cranes to utilize upland food resources. These ponds should be maintained or new ponds created to optimize distribution of upland use by cranes.

1432. Manage vegetation.

Cranes significantly use uplands in winter when relatively open feeding conditions are maintained. Mowing and prescribed burning can provide such areas. Such management practices promote the growth of or enhance the detection and/or palatability of desired food items. Efforts to develop other habitat management practices that increase the habitat base available in wintering areas should continue. These techniques should emphasize use in areas that are most protected from human encroachment and substrate alteration. This task includes management of vegetation in essential or critical roosting habitat on the migration route. In some instances these efforts will require mechanical or chemical removal of established trees or other vegetation that may be discouraging use by cranes.

1433. Maintain suitable riverine roosts.

This task refers to maintaining suitable roosting habitat on the Platte River, Nebraska, or on other rivers used by migrating cranes, by ensuring adequate flows that provide quality roosting habitat and are necessary for scouring invading cottonwoods and willow from the riverbed. Mechanical and chemical control of invading trees may also be required. Purchase or lease of lands bordering key roosts may be necessary to protect the sites from human disturbance.

144. Create wetland habitat.

The whooping crane wintering habitat on and near Aransas NWR should be enhanced to provide for the welfare of an expanding crane population. These efforts should include increased management activities to provide, in a prudent manner, better use of existing protected areas. The paramount consideration

should be programs ensuring adequate habitat and population protection without unnecessarily disrupting other compatible uses of the protected areas. Creation of new habitat would help compensate for habitat losses to various causes and could increase the carrying capacity of the wintering area. Saltwater marsh can be created by filling open water areas to shallow depths using dredged material. Lowering of some areas mechanically, to allow flooding by high tides and collection of runoff, should promote development of salt or brackish marsh areas. Wetland restoration may be needed in areas on the migration route where there has been extensive loss of crane habitat.

2. Increase captive populations.

Until recently, the captive breeding flock has been small. The small captive population has placed constraints on productivity, and may have adversely affected the potential to form socially and sexually compatible pairs. As more breeding pairs become available, the size of the captive flocks, the annual production of eggs and offspring will be increased for ongoing reintroduction efforts and the behavioral, demographic, and genetic management of the captive population will be enhanced.

21. Develop and maintain captive populations.

Patuxent, ICF, and Calgary Zoo should establish and maintain about 40 breeding pairs of whooping cranes (at Patuxent 15, ICF 12-15, and Calgary 10) by year 2000. Birds unable to reproduce could be maintained to rear the chicks of other birds, be used as role models or used in education programs. Within the captive flocks, aviculturists should try to: (1) obtain genetic representation of as many wild pairs as possible; (2) retain in captivity those birds that are especially valuable because of their genetic background; and (3) give careful attention to genetic and demographic considerations to ensure health of the captive population. The studbook keeper will make periodic analyses of the genetics and demographics of captive populations. Results of analyses will be used to guide selection of eggs for transfer from the wild, selection of individuals for pairing, pair productivity, and population demography. Frozen semen banks should be maintained to protect loss of founder lines in captive flocks.

22. Refine avicultural methods and productivity.

The captive breeding centers should optimize the production of whooping cranes in captivity through the application of proven avicultural techniques described in the Crane Propagation Manual (1993 at press) and experimentation in the fields of reproductive physiology, genetics, behavior, and veterinary science.

221. Refine breeding pair management.

Various procedures used in captive propagation of whooping cranes, particularly behavioral and physiological management, need to be developed and/or refined to maximize productivity of captive populations. Research surrogates will be used to accomplish biological research and to develop techniques. Captive centers should

determine optimum techniques for pairing and inducing reproduction of whooping cranes. Pairing attempts for subadult whooping cranes should be initiated when the birds are one and one half to two years old, and should continue until stable pairs are established. Captive breeding centers should determine optimum techniques for handling, pairing, and inducing crane reproduction.

222. Refine incubation procedures.

Whooping crane eggs have greater hatchability rates when incubated naturally for at least two weeks. Patuxent Wildlife Research Center should examine factors involved in incubating crane eggs, both artificially and naturally, to determine the environment required and to enhance overall egg hatchability and flock productivity. Sandhill cranes are available and desirable for natural incubation. Improved mechanical incubation will allow reduction in the numbers of captive sandhill cranes and a savings in costs and pen space.

223. Refine rearing procedures.

Birds destined for release into the wild should either be parent-reared by whooping cranes or isolation-reared using live whooping cranes as models. Whooping cranes should not be reared by other species. Birds reared for captive breeding would initially be parent-reared or exposed to proper imprint cues to assure reproduction. Captive rearing techniques and procedures should be directed at conditioning the birds for release into the wild. When possible captive-reared birds should be exposed to conditions and situations in captivity that they would be facing after release.

224. Refine veterinary procedures.

Long-term survival and productivity of the captive populations will require healthy flocks. The captive centers and the National Wildlife Health Research Center should research the diagnosis, treatment, and prophylaxis of ailments in whooping cranes and other cranes in order to ensure flock health and minimize mortality. Routine health practices should be monitored at all times, and modified as necessary. Included under this task are the recording of health and postmortem findings, and the long-term storage of preserved tissues. Captive disease research needs include leg problems, eye infections, parasite control, drug use and salmonella. Proposed protocols are described in the report entitled Whooping Crane Health Management Workshop (Anonymous 1992).

225. Exchange avicultural information.

Staff of captive centers should exchange annual progress reports on propagation activities. Propagation and veterinary personnel should meet periodically to exchange information and jointly address similar problems, and develop implementation plans and protocol.

23. Maintain captive facilities.

All aspects of Task 2 require adequate facilities for the captive whooping crane populations and surrogate species. Adequate pens are available for maintaining 27 to 30 breeding pairs in the United States. When captive whooping crane populations reach their full production potential, additional pre-release pens may be required. All facilities should be maintained so birds are kept in conditions suitable for their health, safety, and productivity so that recovery and research objectives can be achieved.

3. Establish two additional wild populations.

The Service and CWS should coordinate their research and management efforts to establish at least two discrete, self-sustaining populations, each consisting of a minimum of 25 nesting pairs by year 2020. These populations may consist of one migratory and one nonmigratory population.

31. Develop release techniques.

Test techniques for establishing migratory and non-migratory populations. Factors which need to be examined include age of birds, rearing methods, time of year, and pre-release conditioning procedures, methods for teaching suitable migration behavior, and predator avoidance training. The number of released birds and post-release monitoring should be adequate to insure proper evaluation.

32. Select release sites.

The Service, CWS, and Provincial and State wildlife agencies, in consultation with others as appropriate, should evaluate proposed potential release sites based on the biological needs of the whooping crane, the likelihood of establishing discrete, self-sustaining populations, and the impact of such an introduction on other resources and programs. The Service and CWS will be responsible for selecting proposed sites and ranking them according to their biological suitability. Service and CWS will thoroughly examine proposed release sites and other habitats to be used by released cranes to determine potential conflicting management problems. Examples of problems to be examined are land and water resource development, habitat degradation, impacts on other wildlife species, powerline distribution, disease, predators, and hunting. In particular, the United States role in this project will be to identify a suitable migration route and wintering area for a second migratory population to be reintroduced in Canada late this decade. This introduced population should use wintering habitat discrete from that used by the AWP.

33. Establish nonmigratory population.

Continue to test the soft release of whooping cranes, isolation-reared or parent-reared in captivity, as a means of establishing a non-migratory population in Florida. Monitor the released birds to gather data on habitat use, movements, mortality factors, nesting success, and other data crucial to release success. Periodically evaluate release

success. Implement management techniques throughout the range of the new wild population. Management should be designed to minimize unnecessary conflict with other land and resource uses.

34. Establish migratory population.

Test the guide bird technique as a means of introducing captive-produced whooping cranes into a migratory situation. Test other means of teaching captive-produced birds how to migrate and survive in the wild. These might include socially bonding whooping cranes using ultralight aircraft to guide birds along a predetermined migration route. Monitor the released birds to gather data on habitat use, movements, mortality factors, nesting success, and other data crucial to release success. Periodically evaluate release success.

4. Maintain an information/education program.

The Service, in conjunction with other agencies, should implement a public information and education program to further the well-being of the whooping crane. Under this program, general information will be provided and interest will be generated in the species.

41. Develop media products.

Printed and audio-visual media that are disseminated widely can be very effective in spreading important messages regarding recovery efforts and needs. These media can target various segments of the public and specific needs of the recovery program. Encourage collaboration between the various agencies and organizations that have specific responsibilities or interests in whooping crane recovery.

42. Provide viewing opportunities.

Provide opportunities for the public to view whooping cranes near major use areas wherever such viewing does not interfere with the well-being of the cranes.

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PART III

IMPLEMENTATION SCHEDULE

The Implementation Schedule that follows outlines actions and costs estimated for the recovery program. It is a guide for meeting the objective discussed in Part II of this Plan. This schedule indicates task priorities, task numbers, task descriptions, duration of tasks, the responsible agencies, and estimated costs. These actions, when accomplished, should bring about the recovery of the species and protect its habitat. It should be noted that the estimated monetary needs for all parties involved in recovery are identified and, therefore, Part III reflects the total estimated financial requirements for the recovery of this species.

Recovery task priorities are defined as follows:

Priority 1 - An action that must be taken to prevent extinction or to prevent the species from declining irreversibly in the foreseeable future.

Priority 2 - An action that must be taken to prevent a significant decline in species population/habitat quality, or some other significant negative impact short of extinction.

Priority 3 - All other actions necessary to meet the recovery objectives.

ACRONYMS USED

Fish and Wildlife Service Programs

FA	Federal Aid
ES	Ecological Services
LE	Law Enforcement
OMBM	Office of Migratory Bird Management
PA	Public Affairs
RW	Refuges and Wildlife

Others

NBS	National Biological Survey
BR	Bureau of Reclamation
CG	Coast Guard
COE	Army Corps of Engineers
FAA	Federal Aviation Authority
FERC	Federal Energy Regulatory Commission
FGF	Florida Game and Fresh Water Fish Commission
ICF	International Crane Foundation
PRT	Platte River Whooping Crane Habitat Maintenance Trust
PS	Private Sector
NAS	National Audubon Society
NGO	Non-Government Organization
WCCA	Whooping Crane Conservation Association

RECOVERY PLAN IMPLEMENTATION SCHEDULE

Priority #	Task #	Task		Responsible Party			Fiscal Year Cost Est. ($000)		
		Description	Duration	Reg.	Prog.	Other	1	2	3
1	123	Minimize Chemical Spills	Ongoing, Continuous	2,6	EC, ES	CG COE	50	50	50
1	14	Identify, Protect, Manage, and Create Habitat	Ongoing, Continuous	2,6	RW ES	COE, BR CG	35	35	35
1	142	Protect Habitat	Ongoing, Continuous	2,6	RW ES	COE, BR CG	50	50	50
1	1421	Prevent Contamination of Habitat	Ongoing, Continuous	2,6	EC RW	CG COE	10	10	10
1	1422	Prevent Erosion of Habitat	Ongoing, Continuous	2	ES RW	COE CG	205	205	50
1	1423	Regulate Deposition of Dredge Spoil	Ongoing, Continuous	2	ES	COE	10	10	10
1	1424	Maintain Freshwater Inflows	Ongoing, Continuous	2,6	ES	COE, BR FERC	5	5	5
2	1	Increase AWP	Ongoing, Continuous	2,6	RW ES	NAS, WCCA	40	40	40
2	11	Monitor Movements	Ongoing, Continuous	6	ES	PS Agencies	15	15	15
2	12	Reduce Mortality	Ongoing, Continous	2,6	RW, ES OMBM		50	50	50
2	121	Prevent Shooting	Ongoing, Continuous	2,6	ES LE	States	60	60	60
2	122	Diminish Disease Losses	Ongoing, Continuous	2,6	ES	States NBS	30	30	30
2	124	Diminish Collisions	Ongoing, Continuous	2,6	ES	Utilities FERC	10	10	10

Priority #	Task #	Task		Responsible Party			Fiscal Year Cost Est. ($000)		
		Description	Duration	Reg.	Prog.	Other	1	2	3
2	13	Restrict Detrimental Human Activities	Ongoing, Continuous	1,2,4,6	RW ES, LE	CG COE	20	20	20
2	141	Identify Essential Habitat	5 years	2,6	ES		10	10	10
2	143	Manage Habitat	Ongoing, Continuous	1,2,4,6	RW ES	PRT NAS	275	275	275
2	1431	Maintain Upland Water Sources	Ongoing, Continuous	2	RW		5	5	5
2	1432	Manage Vegetation	Ongoing, Continuous	2	RW	PRT NAS	50	50	50
2	1433	Maintain Suitable Riverine Roosts	Ongoing, Continuous	6	ES	NAS PRT	100	100	100
2	3	Establish Two Additional Wild Populations	25 years	1,2,3,4,6	ES, LE RW	States NBS	14	14	14
2	31	Develop Release Techniques	10 years	1,2,3,4,6	ES RW	NBS WCCA	45	45	45
2	32	Select Release Sites	5 years	2,3,6	ES	PRT	5	5	5
2	33	Establish Non-Migratory Population	12 years	2,4	ES	FGF NBS	235	235	235
2	34	Establish Migratory Population	20 years	1,2,3,4,6	ES RW	States NBS	162	162	162
2	131	Restrict Construction Periods	Ongoing, Continuous	1,2,6	ES RW		5	5	5
2	132	Restrict Aircraft Altitude	Ongoing, Continuous	2	FAA		5	5	5
2	133	Restrict Other Detrimental Human Activities	Ongoing, Continuous	1,2,4,6	ES	FGF	10	10	10

Priority #	Task #	Task		Responsible Party			Fiscal Year Cost Est. ($000)		
		Description	Duration	Reg.	Prog.	Other	1	2	3
2	2	Increase Captive Populations	10 years	2	ES	WCCA ICF NBS CWS	200	200	200
2	21	Develop and Maintain Captive Populations	Ongoing, Continuous	2	ES	ICF NBS	185	185	185
2	22	Refine Avicultural Methods and Productivity	10 years	2		NBS ICF	100	100	100
2	221	Refine Breeding Pair Management	10 years	2		NBS ICF	50	50	50
2	222	Refine Incubation Procedures	5 years	2		NBS ICF	50	50	50
2	223	Refine Rearing Procedures	10 years	2		NBS ICF	100	100	100
2	224	Refine Veterinary Procedures	10 years	2		NBS ICF	50	50	50
3	144	Create Wetland Habitat	Ongoing, Continuous	2	ES RW	NGO COE	50	50	50
3	225	Exchange Avicultural Information	Ongoing, Continuous	2	ES	NBS ICF	5	5	5
3	23	Maintain Captive Facilities	Ongoing, Continuous	2	ES	NBS ICF	100	100	100
3	4	Maintain I&E Program	Ongoing, Continuous	2,4,6,9	PA	States WCCA	5	5	5
3	41	Develop Media Products	Ongoing, Continuous	2,9	PA	WCCA	5	5	5
3	42	Provide Viewing Opportunities	Ongoing, Continuous	2,4,6	ES RW	FGF	10	10	10

PART IV. APPENDIX

Appendix A. List Of Individuals And Agencies Invited To Review Plan Or Providing Review Comments

Bureau of Reclamation, Regional Director, Billings
Canadian Wildlife Service, Dr. Roger Edwards
Central Nebraska Public Power and Irrigation District
Federal Energy Regulatory Commission, Executive Director
International Crane Foundation, Director
Monte Vista Crane Committee, Chairman
National Audubon Society, Regional Representatives
National Wildlife Federation, Executive Vice President
North American Crane Working Group, Wendy Brown
Platte River Whooping Crane Habitat Maintenance Trust, Director
Socorro Chamber of Commerce, New Mexico

State Wildlife Agencies
- Executive Director, Colorado Department of Natural Resources
- Executive Director, Florida Game and Fresh Water Fish Commission
- Director, Idaho Fish and Game Department
- Secretary, Kansas Department of Wildlife and Parks
- Director, Montana Department of Fish Wildlife and Parks
- Director. Nebraska Game and Parks Commission
- Director, New Mexico Department of Game and Fish
- Director, North Dakota Game and Fish Department
- Director, Oklahoma Department of Wildlife Conservation
- Director, South Dakota Game, Fish and Parks Department
- Executive Director, Texas Parks and Wildlife Department
- Executive Director, Utah State Department of Natural Resources
- Director, Wyoming Game and Fish Department

Texas Waterway Operators Association

U.S. Army Corps of Engineers,
- District Engineer, Galveston
- District Engineer, Omaha

U.S. Coast Guard
- Office of Merchant Marine Safety, Security and Environmental Protection

U.S. Fish and Wildlife Service
- Regional Director (AES), Region 1
- Regional Director, Region 2 (ALE, ARW, APA, Supervisors of field offices in New Mexico, Oklahoma, and Texas
- Regional Director (AES), Region 4
- Regional Director (AES), Region 6
- Regional Director, Region 8 (Now National Biological Survey)

Migratory Bird Management Office, Washington, DC
Biologist, Seney NWR
Leader, Ohio Cooperative Fish and Wildlife Research Unit

Whooping Crane Conservation Association, President and Trustees

Appendix B. Principal Comments Received On The Whooping Crane Recovery Plan Technical/Agency Draft

The Notice of Availability of the Technical/Agency Draft of this Recovery Plan for public review was published in the Federal Register on June 10 of 1993. All comments, even those received after the 30-day comment period, were considered. The Service distributed about 60 copies of the Draft Plan and received 13 comment letters.

The comments discussed below are a composite of those received. Similar comments are grouped together. Substantive comments which question aspects of the Plan are discussed here. Editorial comments and supportive comments are not discussed. All comments received are on file in the Whooping Crane Coordinator's office, at the Southwest Region regional office of U.S. Fish and Wildlife Service. Time spent by each reviewer and comments provided are appreciated.

Comment: The downlisting goal of 40 pairs plus 25 pairs in each of two other populations is not based on scientific estimates of population viability.

Response: The downlisting goal in the three populations is based on Samson's (1983. Minimum viable population - A review. Natural Areas J. 3:15-23) estimate of the number of isolated breeding organisms necessary to prevent inbreeding over the short-term. The goal identifies a point at which downlisting could occur if the population size did not drop below that minimum in the three populations during a decade. However, attaining the 25 pair goal does not mean that recovery efforts would be discontinued. It is hoped that each population will continue to grow because 25 pairs would be insufficient to maintain genetic diversity and to ensure survival of the species long-term. The Service places emphasis on the multiple population goal, believing that a single large population is still highly vulnerable to extinction due to a catastrophic event. These populations can be managed as a meta-population by manipulating the genetic exchange. Population viability is a young science and there are differing theories (estimates) on how many individuals are necessary for population viability. As the science matures there should be better data on population sizes required for species survival. The current downlisting goal is unlikely to be attained before year 2020. If the present rate of growth continues in the AWP, there will be 500 individuals in that population including about 150 pairs. There will be opportunities to modify the downlisting goal over the next 27 years if that becomes appropriate as scientific knowledge increases.

Comment: There should be down-listing and delisting criteria based on the possibility that the AWP will forever be the only reproducing wild population.

Response: The Service, supported by the recovery team, does not agree that downlisting and delisting goals should be established on the assumption that the AWP may be the only self-sustaining population. Real security for the whooping crane as a species will only be possible if several populations can be established. As long as a single population exists, wintering on a restricted area of the Texas coast, the population remains vulnerable to eradication in the wild due to a contaminant spill along the Gulf Intracoastal Waterway. A very large AWP containing 1,000 individuals might warrant downlisting, but not delisting unless it expands its wintering range over a larger area of the Texas Gulf Coast. In 1988,

an addendum to the 1986 Recovery Plan was prepared stating that a single, large wild population cannot substitute for the provision of multiple populations.

Comment: The Plan assumes, without identifying limiting factors, that the availability of migratory habitat is inhibiting population growth. After so assuming, the Plan calls for making all of the migratory habitat enhancements in the Big Bend reach of the Platte River.

Response: The Service does not assume that migration habitat is limiting population growth. The whooping crane has the highest long-term recruitment rate (13.9 percent) of any North American crane population. However, secure migration habitat is essential for safety of the birds and necessary for species recovery. Migration has been identified as the period when losses of fledged whooping cranes are highest. Seventy six percent of the losses in the RMP and 60 to 80 percent of the losses of fledged whooping cranes in the AWP occur during migration. The Platte River has been identified as an area of concern because of its historical importance to whooping cranes and the degradation of that habitat due to upstream water withdrawal and retention. The Service is continuing to survey wetland habitat throughout the migration pathway of the AWP to identify other areas where migration stopover habitats for whooping cranes may be deficient. The Platte River is the principal area where migration habitat has been enhanced but not the only area.

Comment: The possibility of sighting whooping cranes is not the principal focus of a majority of the tourist visitations to the Central Platte Basin, but is the attraction of the massive sandhill crane migration.

Response: Correct. The main attraction along the Platte River is the large number of sandhill cranes as we stated. Whooping cranes are more likely to be seen near the end of the sandhill crane migration and are a significant attraction when present. The discussion in the Recovery Plan is intended to provide an example of the economic benefit which can accrue from the presence of either crane species.

Comment: The economic figures of Lingle 1992 are highly inflated and misrepresent the economic impact of whooping crane migration upon the Central Platte Basin.

Response: The comment provides an opinion without supporting data. The paper by Lingle discusses crane-watching along the Platte and makes it clear that the principal attraction is sandhill cranes. The Service believes the publication merits use as a reference in this Plan.

Comment: The recovery team's discussion of migratory habitat along the Platte River fails to consider roosting habitat outside of riverine sites and adjacent wetlands even though earlier discussions acknowledge their use. The Plan fails to recognize the importance of managing and protecting non-adjacent wetlands (not bordering the Platte River) as migration habitat.

Response: The Service is aware that whooping cranes make some use of the Rainwater Basin along the Platte River as migration stopover habitat. Many of the historical wetlands in the basin have been drained or diminished in size. Most of the remaining wetlands have a history of outbreaks of avian cholera. Use of the chronic cholera site presents a health hazard to whooping cranes and many waterfowl. The Service is aware also of the

importance of other types of migration habitat in Nebraska and elsewhere. The Recovery Plan discusses and references the studies by Stahlecker and by Howe which describe their use and availability.

Comment: The Plan fails to state which areas have been identified as essential or critical habitat. Essential habitat should be defined.

Response: Critical habitat is defined by the Endangered Species Act as specific areas on which are found those physical or biological features essential to the conservation of the species and which may require special management considerations or protection. Essential habitat is not defined by the Endangered Species Act and has no legal connotation, but can be defined as being of the utmost importance. The Service has added a brief description of the areas currently designated as critical habitat.

Comment: The assertion that there has been considerable alteration and destruction of natural wetlands, rivers, and streams is not supported by any analogous discussion in the Plan. The Plan does not detail any evidence of the threat posed to migratory habitat.

Response: Recovery plans are not intended to be all inclusive. Numerous publications describe the loss of wetland habitats in the United States and the Platte River. The Service believes there is no need to repeat the discussion of materials generally accepted as fact by the scientific community and thoroughly described elsewhere. The Service suggests you request the publication by T.E. Dahl. 1990. Wetlands losses in the United States 1780's to 1980's. U.S. Department of the Interior, Fish and Wildlife Service, Washington, D.C. 21 pp. The lower 48 states have lost 53 percent of their wetlands during this interval.

Comment: The Recovery Plan fails to recognize and discuss the Nebraska State Plan.

Response: Discussing the many Platte River management plans that have been presented to the Federal Energy Regulatory Commission (FERC) by several groups and agencies, including the Nebraska State Plan, is unnecessary and would serve no useful purpose in the Recovery Plan. FERC has not yet made a decision on a river management plan that will be imposed on the power generation license. The FERC-adopted plan can be discussed in a future revised Recovery Plan.

Comment: The citation of Allen (1952) to justify an assertion that the Platte is a major stopover site for whooping cranes is inconsistent with the 1986 revision of the Plan which stated sightings prior to 1940 are unreliable because "such sightings would not necessarily reflect more recent but unrecorded, use of stopover areas (1986 Whooping Crane Recovery Plan, Appendix C).

Response: The statement from Appendix C of the 1986 Recovery Plan refers to sightings which describe stopover use in recent decades. The work of Allen (1952) is appropriate to describe the historical importance of the Platte before its habitat became severely degraded due to upstream water storage and diversion. Such historical use indicates the potential value for the area wherever the habitat can be maintained for use by current and expanded future populations of whooping cranes.

Comment: A number of comments suggested providing further details or information on a variety of topics.

Response: Recovery plans are not intended to be monographs on a topic. The Whooping Crane Recovery Plan probably contains the most comprehensive narrative of any recovery plan for a species listed under the Endangered Species Act. The Plan covers key topics which the Service believes are pertinent. The readers are encouraged to review the abundant literature references for more detailed information on these topics.

Comment: Use of the word population to refer to the whooping cranes in the Rocky Mountains and Florida. I assume a biological population is referred to; this implies an interbreeding group of organisms and is therefore not the appropriate term to describe the individuals in either of these two areas.

Response: The word is used as defined by Webster, to describe the total number of individuals occupying an area. It is used only as a convenient means of identifying the groups of individuals in a specific geographic area and is not intended to have a biological connotation about breeding.

Comment: The word successful appears several times in this Recovery Plan but is never defined.

Response: The Service believes Webster's definition of successful is appropriate, "resulting in a degree or measure of success".

Comment: It should be noted that the original premises on which Grays Lake was selected as a reintroduction site have changed. Grays Lake marsh has proven not to be "excellent crane breeding habitat".

Response: Grays Lake NWR continues to support good crane nesting habitat. Its productivity varies, contingent upon wet and dry rainfall periods. It has the highest nesting density of any North American crane habitat of this size. The Long-term productivity continues to be good despite unfavorable water withdrawal by the Bureau of Indian Affairs for downstream irrigation. The wet/dry cycles probably contribute to site productivity, promoting decay of organic materials and release of their nutrients after the dry cycles end. The same patterns make the prairie pothole country productive for waterfowl.

Comment: In view of the whooping crane X sandhill crane hybrid chick produced in 1992, the statement "field observations indicate that behavioral incompatibilities between the two species generally prevent mixed species pairing and subsequent hybridization" requires further explanation and mention of imprinting problems.

Response: The quote mentioned was on page 38 of the draft report. In that paragraph we also referenced several sources for further details on the cross-fostering experiment. Imprinting and the hybrid chick were discussed later on pages 43 and 44. The statement that "behavioral incompatibilities between the two species generally prevent mixed species pairing" refers to normal behavioral differences between the two species. The hybrid chick produced in 1992 was the first recorded instance of cross-breeding despite the frequent

association between the two species in the Rocky Mountains and the Great Plains. Research suggests that cross-fostering results in female young sexually attracted to males of the foster-parent species and male young who are less discriminant and may be equally attracted to females of the foster parent species and their own species. In theory then, the female whooping cranes would seek male sandhill cranes for their mates. But the male sandhill cranes, being appropriately imprinted on females of their own species, would reject the advances of female whooping cranes. The male whooping crane would be rejected by cross-fostered female whooping cranes which are imprinted on male sandhill cranes. The male whooping crane would also, normally, be rejected by female sandhill cranes which would be imprinted on male sandhill cranes. The Service does not know why, in 1992, a male whooping crane found a receptive female sandhill crane. Perhaps she was one of the sandhill crane chicks which whooping cranes helped the sandhill parents raise at Grays Lake NWR and her imprinting was thus confused.

Comment: "The lack of pairing and reproduction, prolonged drought on the summer area, and the high mortality led to discontinuing the egg transfers in 1989." These are good reasons for discontinuing this project. Many adverse factors (avian tuberculosis, power lines in high-use areas, disturbance on wintering areas, limited habitat, etc.) not only at Grays Lake but at other sites along the migration route, contributed to poor survival of these birds. In future reintroductions of migratory whooping cranes, breeding grounds, migration routes, and wintering areas should be selected that minimize the sources of mortality that were incurred by birds in the Rocky Mountains.

Response: The Service agrees in general with the statement. However, some of the factors causing high mortality in the RMP may have been due to the cross-fostering technique rather than the habitat. Some evidence indicates that predator losses are increased as a consequence of communication difficulties between the foster parents and whooping crane chicks. Power line and fence collisions may be increased because the whooping cranes are less maneuverable and when following sandhill cranes they may collide although the sandhills can avoid the obstacle. The habitat features of the Rocky Mountains, with some exceptions, have not been proven to be unsuitable for supporting a whooping crane population. The Rocky Mountain habitat continues to support a healthy sandhill crane population and might support a self-sustaining whooping crane population if a satisfactory release technique is identified.

Comment: There is no explanation of why central Florida was chosen as a reintroduction site rather than Okefenokee NWR.

Response: For the sake of brevity the Recovery Plan also does not indicate why two other sites in Florida were not favored over the Kissimmee Prairie site. The basis for these selections was: (1) Okefenokee apparently has a lower base productivity and would present very difficult and expensive access for the daily monitoring essential for evaluating the reintroduction, and (2) Florida sites provided smaller habitat areas, greater likelihood of further human population growth, and a greater probability of future habitat reductions associated with land use changes.

Comment: "There are inherent mortality risks associated with migration that act to the greatest extent on birds of the year, potentially hindering efforts to establish new migratory

populations" (Draft Recovery Plan). That statement might be true for the RMP but it is not true for the population at Seney NWR.

Response: The principal mortality period for fledged whooping cranes in the AWP and the RMP was fall and spring migration. Drewien et al. (1989) noted that 76 percent of their losses occurred during migration period. Lewis et al. (1992) noted that losses (60-80 percent) in the AWP were apparently heaviest during migration. These increased losses may be due to the new hazards the birds face which juveniles have not previously experienced (power lines, fences, hunting, some predators, disease). There are no whooping crane populations in the Great Lakes area, consequently we cannot comment on whether their loss patterns in that area might be similar to those of the AWP or RMP. Sandhill crane data are not necessarily indicative of mortality factors and rates which characterize whooping crane populations using the same geographic areas. The Service agrees that sandhill cranes in the Seney area do not appear to experience significant losses during migration.

Comment: Migratory cranes will disperse more widely as subadults than nonmigratory cranes, hampering or forestalling formation of pair bonds. These unsubstantiated assumptions are then used to justify establishment of a nonmigratory rather than a migratory flock of whooping cranes.

Response: Drewien et al. (1989) found that when female whooping cranes returned to summer areas they generally dispersed widely from the area where they hatched. In contrast, male whooping cranes had a greater propensity for returning to Grays Lake and establishing a defended territory near where they hatched. These tendencies of the two sexes would theoretically diminish the likelihood of inbreeding but, when small population numbers are present, such dispersal may limit the opportunity for whooping cranes to find a compatible mate. Likewise, Nesbitt found that female Florida sandhill cranes tended to disperse more widely than males. The 1988 decision to concentrate on establishing a nonmigratory population before trying to reintroduce another migratory population, was primarily due to the lack of any proven technique for establishing a migratory population.

Comment: Are there any records of whooping cranes breeding in open saw palmetto prairie?

Response: There are no records of whooping cranes breeding in any non-wetland sites. There also are no confirmed records of whooping cranes breeding in Florida although early naturalists reports suggest whooping cranes were resident year round. Habitat in the Kissimmee Prairie release area is similar to areas near White Lake, Louisiana, where whooping cranes nested into the 1930s.

Comment: With reference to the Florida reintroduction, the statement in the Plan that additional pens will be built in the future, even before the 1993 experimental release to determine suitability of the area has been evaluated, suggest that the Florida release will proceed regardless of the outcome of the experimental release.

Response: In the paragraph following the one mentioning additional pens, the statement is made that additional releases may be made if the initial (first two years) results are

favorable. Each project is reviewed annually. The Federal Register publishing the final rule on establishment of a nonessential experimental population in Florida (January 22, 1993) noted page 5650 "Project progress will be evaluated annually." There is no intent to continue projects irrespective of their outcome nor has that occurred in the past. The only other reintroduction experiment involving whooping cranes was the cross-fostering study. The cross-fostering was terminated after sufficient evidence accumulated to indicate the technique caused improper sexual imprinting and may contribute to high mortality in released birds.

The mention that additional pens would be built in the future was meant to convey the intent to have a series of release enclosures scattered over the Kissimmee Prairie, not simply one or two release pens. The research at Grays Lake NWR indicated that male whooping cranes evidence strong philopatry and a tendency to establish a nesting territory near their natal site. Females, in contrast, dispersed in random directions from their natal area, apparently seeking an appropriate mate. The scattering of sexually mature females is one of the early theories for failure of appropriate pairing and reproductive activity among the cross-fostered cranes of the Rocky Mountains. The release enclosures in Kissimmee Prairie are being scattered to increase the likelihood that dispersing females in these small populations will encounter suitable mates on territories. However, they will be constructed only on an as needed basis and only if the project continues.

Comment: It appears that a project, once approved by the Recovery Team/Service, may be continued indefinitely regardless of the level of success or failure. This shortcoming has been demonstrated by the Grays Lake cross-fostering experiment. Any reintroduction should be allowed to continue only if the results so warrant, not at all costs.

Response: Projects are evaluated at least annually by the United States and the Canadian Federal agencies and recovery teams. The Grays Lake cross-fostering experiment is not an example of a project continued indefinitely regardless of the level of success. The project began in 1975. The last eggs were transferred in 1988 and the experiment terminated in 1989 as soon as there were sufficient data to document the likelihood of improper imprinting and, when modelling showed that a self-sustaining population was unlikely to be achieved using the cross-fostering technique, even if the birds began breeding. Wild whooping cranes require four to five years to reach sexual maturity. Only small numbers of eggs were available in the early years of the experiment and females experienced much heavier mortality than males. Consequently, it was not until the mid-1980s that a reasonable sample of females reached sexual maturity and allowed biologists to recognize that there might be a problem, other than small numbers, contributing to the lack of pairing. Other theories for the absence of pairing (a small number of reproductive-age females and their wide dispersal prevented finding compatible mates) prevented an earlier decision until research in captivity and the wild provided evidence of improper sexual imprinting. The experimental work in the years since 1989 has been directed at promoting pairing (translocation and forced pairing studies) of the remnant birds and gaining as much information as possible from these birds. Reintroductions should continue only as long as the results warrant.

Comment: There is no mention of Seney's suitability as a reintroduction site. Seney was eliminated in 1988 only because it represented a migratory situation. The only legitimate

reason for discarding Seney at that time was lack of a suitable reintroduction technique. Although the technique remains to be completed, isolation rearing/gentle release (Urbanek and Bookhout 1992; Urbanek and Bookhout 1993, in press) has already been developed to an operational level. The area appears suitable as a whooping crane reintroduction site (Urbanek 1990 and unpubl. data).

Response: The Recovery Plan does not discuss suitability of other potential release areas (Okefenokee, other sites in Florida, Wisconsin, Minnesota). Such areas will likely receive more attention in future Plan revisions after the Florida reintroduction efforts are adequately evaluated and a suitable reintroduction technique is developed for a migratory population. The Seney area appears suitable as a whooping crane reintroduction site. As noted in the draft revision of the Recovery Plan, the technique developed for sandhill crane reintroduction by Urbanek and Bookhout needs to be tested on whooping cranes. Data collected during the cross-fostering study indicates that young whooping cranes were not able to adequately integrate into flocks of sandhill cranes and accompany them unless the sandhill crane foster parents were present to protect them. Thus, captive-reared whooping cranes also may not learn appropriate migration and wintering areas by flocking with wild sandhill cranes. Recent observations during the guide bird research indicate that young captive-reared whooping cranes imprinted on their own species do not have a desire to flock with sandhill cranes.

Comment: On page 48 "The authors noted the need for similar studies on captive-reared whooping cranes to see if they will associate with and learn migration from resident wild sandhill cranes", but then adds "these studies should occur whenever sufficient funds and whooping crane eggs are available without detracting from other ongoing reintroduction studies. The study site should be part of an approved reintroduction location." From the biological standpoint, the research at Seney should certainly be carried forward with whooping cranes. It is foolish to discontinue a successful effort when success has been so difficult to come by elsewhere.

Response: The research at Seney in which captive-reared sandhill cranes were released into the wild, integrated with wild sandhill cranes, and successfully migrated and returned to the release area, is a valuable piece of research. The unfortunate crane herpes health problem among the red-crowned cranes released in follow-up studies prevented further evaluation of the technique with white cranes closely related to whooping cranes. The specter of crane herpes at the captive-rearing site at Seney, its unknown source, and the potential for exposure of any whooping cranes that might be reared at the same facility, casts a cloud of doubt about the wisdom of conducting the research at that site. The technique pioneered by Horwich 1989, Archibald and Archibald 1992, and Urbanek and Bookhout 1992 should be tested with whooping cranes. It may be that the current guide bird research will sufficiently answer the question about whether captive-reared whooping cranes will integrate with wild flocks of sandhill cranes and learn migration and survival techniques from them.

If the technique can be tested at an approved reintroduction site it simplifies the process. Testing the technique at an unapproved reintroduction site would mean the birds would have to be recaptured after the research was complete. It is unlikely that such birds will be placed into another wild population without the likelihood that they would attempt to return

to their original release area. While in the wild, the birds may be exposed to avian tuberculosis. There is no technique for identifying tuberculosis-infected birds in the early stages of the disease. Therefore the birds could not be added to existing captive flocks without posing a significant disease hazard. It is currently Service policy to not ship to existing captive flocks (Patuxent, Calgary, ICF) any whooping cranes recovered from the wild. Whooping cranes surviving after an experiment at an unapproved reintroduction site would have to be recaptured but could not be placed where they might jeopardize existing captive populations nor used to supplement existing wild populations.

Comment: The section entitled Guide Bird Experiment appears to be a plan to save the Grays Lake project.

Response: The goal of the United States and Canadian recovery efforts is to meet recovery goals for downlisting and delisting. There is no plan to "save" the Grays Lake project but the goal is to establish self-sustaining migratory and nonmigratory wild populations where ever that is feasible. The guide bird experiment tests one technique for introducing a migratory population while continuing to make use of remnant birds in the RMP. The cross-fostering research has been terminated but the federal agencies are still endeavoring to reestablish a second migratory population in North America in the near future. The first priority in the United States is to fully evaluate the Florida reintroduction effort. The first priority of the Canadian effort is to establish a second migratory population in Canada. A suitable technique is needed to reintroduce whooping cranes late this decade to a site not yet selected in Canada.

Comment: Since 1989 the position of the Recovery Team has been that all available whooping cranes are committed to the release program in Florida and to captive propagation, and therefore no eggs are available for reintroduction technique development at other sites. Yet, in an abrupt action by decision-makers in late 1992, eggs are suddenly available for technique development at Grays Lake. Why?

Response: The Memorandum of Understanding with Canadian Wildlife Service, signed in April 1990, included a commitment of providing, from the United States captive facilities, 16 to 24 whooping cranes to the new captive facility to be developed in Calgary, Canada. These birds could be provided over 4 years or, preferably in a shorter time interval, so the Calgary facility could be producing birds in the late 1990's. The Service had a goal of releasing 9 to 12 whooping cranes in Florida in late 1992 or early 1993. The best estimate of availability of fledged birds had to be based on immediate past production rates, although it was hoped that production would increase as more pairs reached breeding age in the wild and captivity. The 1989 through 1991 production rates were those on which the Service relied to judge availability of whooping cranes for Calgary, Florida, and other uses. The production of fledged birds in 1989 through 1991 were 11, 11 and 7 respectively. Using the average of 9.6 birds fledged per year it did not appear that we would have any birds in excess of needs to stock the Calgary facility and reintroduce birds in Florida. However, in late summer of 1992, 28 whoopers were fledged and in 1993, 35 fledged. These fortuitous increases in production made it possible to meet the existing obligations and to initiate the guide bird research. The guide bird research did receive first priority for use of any "surplus" production.

Comment: Although the guide bird experiment may provide some useful information, it would not be practical on a large scale even if successful, and certainly long-range planning based on this technique is premature and should not be part of the Recovery Plan.

Response: The guide bird experiment is part of the Plan. Its future use as a reintroduction technique will depend on results of the experiment. It is premature to say the technique will not be practical on a large-scale. There is presently no evidence that any other technique will be more suitable. The Service will utilize whatever technique proves to produce a good return for the number of eggs or young birds invested and results in "wild" birds exhibiting appropriate behavior. Long-range planning is appropriate as long as appropriate contingencies are included to make allowance for unpredictable events.

Comment: The statement "The cross-fostering experiment successfully produced wild whooping cranes capable of migrating and surviving in a challenging environment" is not true if success is measured in return per number of eggs expended.

Response: Success is measured in terms of achieving some of the objectives listed in the original cross-fostering research proposal. Hypotheses being tested included the assumptions that the foster-reared whooping cranes would learn appropriate migration and wintering patterns, food habits, and survival behaviors from the foster-parents. The whooping cranes did learn the migration pathways and winter sites of their foster-parents. They mimicked the feeding behavior of the parents and a portion of the birds survived. The term success is defined by Webster as noted earlier.

Comment: "The completion of the 2-year project will provide another decision point about future efforts in the Rocky Mountains." Plans to conduct another large-scale reintroduction on this migration route are unwarranted, especially when better reintroduction sites and more successful reintroduction programs are available.

Response: At this time there are no plans to start another large-scale reintroduction on this migration route, but there is no basis for excluding the Rocky Mountains as one of several possible future reintroduction sites. The studies referred to beyond 1994 would have the dual objective of (1) testing other reintroduction techniques for use where the birds would have to migrate and (2) further evaluating the Rocky Mountain area as a site to reintroduce whooping cranes. The statement that there are better reintroduction sites and more successful reintroduction programs are available is unfounded because the only other release effort is in Florida and it is premature to draw conclusions about that site. Work with sandhill cranes has shown that they have some merit for surrogate research but also that there are distinct differences between the two species. For example, whooping cranes are more vulnerable than sandhill cranes are to avian tuberculosis and collisions with aerial lines. Studies of reintroduction techniques and sites using sandhill cranes may not have direct applicability to whooping cranes. That is why research on the reintroduction techniques using whooping cranes is recommended.

Comment: Referring to page 59, paragraph 1, "Factors which need to be examined include age of birds, rearing methods, time of year, and pre-release conditioning procedures." This has already been done and conclusions drawn (Urbanek and Bookhout 1992). The Service suggests that birds be (1) isolation (puppet/costume)-reared (2) at the release site, and they

be (3) gentle-released as flight-capable juveniles (4) in late summer or autumn of the hatch year.

Response: The comment presupposes that the research accomplished with sandhill cranes is directly applicable to whooping cranes. The listed factors remain to be tested on whooping cranes, hence the statement in the Plan.

Comment: In the recovery portion of the Draft Plan, where they discuss establishing two additional wild populations, you mention "The FWS and CWS will be responsible for selecting proposed sites and ranking them according to their biological suitability." The criteria for ranking proposed sites should be based on biological considerations only, these criteria should be explicitly stated by the recovery team, all available biological data should be used in ranking, and no site should be excluded from consideration for non-biological reasons.

Response: The Service agrees on the importance of biological criteria as being paramount in selecting a reintroduction site. Biological criteria were established by the recovery team in the early 1980s and used in selecting the Florida release site. However, biological events do not occur in a vacuum and it is not appropriate to totally exclude nonbiological aspects from the selection process.

Comment: Why is testing the guide bird technique given such high priority as a means of introducing captive-produced whooping cranes into a migratory situation? Too much attention is given to the guide bird project as a means of starting a migratory population. Other methods are available that would be better, faster and more direct.

Response: The guide bird study is given no greater priority than the other techniques mentioned. It was initiated first because the United States and the Canadian recovery teams and agencies were deliberating how to make good use of the birds surviving in the RMP and these birds provided one means of introducing properly imprinted, captive-produced whooping cranes into a migratory situation where they might learn a preselected migration route. It was necessary to implement this research while the RMP contained sufficient surviving members to provide the "guide" birds. The guide bird proposal is described in enough detail so the readers can understand the approach and because the research is being implemented. There was no existing publication describing the technique which could be referenced as we did the work by Urbanek and Bookhout. Although not described in our earlier draft of the revised Recovery Plan, other experimental techniques, such as evaluating the use of ultralight aircraft and of truck transport to teach whooping cranes an appropriate migration route will be investigated. These techniques were discussed at length in the 1992 meeting of the recovery team. Research on use of an ultralight to train migratory cranes was proposed by Drs. George Gee and Dave Ellis. At this time there are no research data on whooping cranes which provide a basis for evaluating other methods which are "better, faster," or "more direct." Those statements presuppose results which have not been tested.

Comment: I find it remiss that the U.S. Recovery Plan Implementation Schedule excludes Region 3 from participation in whooping crane recovery activities, particularly the tasks to

establish two additional wild populations, develop release techniques, select release sites, and establish migratory populations.

Response: Region 3 is not excluded from involvement. The schedule reflects ongoing and immediate future projects (next 3 years). The ongoing projects in Regions 2 and 6 are a historical consequence of the only surviving wild population being in those regions. Region 1 has been involved due to the RMP population and the reintroduction experiment begun in 1975 which included their region. Region 8 (now the National Biological Survey) has been involved in reintroduction experiments and propagates the whooping cranes at Patuxent Wildlife Research Center. Region 4 is involved due to the reintroductions in Florida. Region 3 has been invited to participate in recovery team meetings in the past but chose not to attend because they had no active project within their administrative region. The Florida and Canada reintroductions, if successful, would attain the downlisting goals and the goals for delisting have not yet been identified. Since the release site has not been selected in Canada, we are unable to predict whether the migration route of the second migratory flock in Canada would include portions of Region 3. A future revision of the Plan will likely identify a more active goal for Region 3 and, when sufficient birds are available, include a reintroduction effort in that former nesting habitat.

Comment: A renewed Grays Lake project aimed at another large-scale reintroduction attempt at that site or other sites in that migration route appears to be promoted. I do not see how support for this proposal can be justified in view of the large loss of eggs and failure of previous attempts in this area.

Response: The Service and the recovery team have made no recommendation on work in the Rocky Mountain area beyond the guide bird research which terminates at the end of Fiscal Year 1994. The Draft Recovery Plan noted that following the guide bird research there would be another decision point and an opportunity for review and recommendations by all interested parties. If additional birds are released in the Rocky Mountains using the guide bird technique or other techniques, the releases would have the purpose of further testing survival in a sample of 10 to 20 birds. Such releases would help determine whether a significant part of the low survival in the cross-fostering research was a consequence of the technique and inter-species differences in communication, behavior, and flight ability, and not a consequence of poor habitat conditions.

Comment: A major deficiency of the Plan is the lack of standards by which to evaluate the success or failure of efforts to effect recovery of the whooping cranes. For example, survival one year after release is a suitable standard; e.g., if less than 50 percent of experimental birds survive one year after release, the project is terminated. Without standards, work continues, and continues, and at what cost, and for what result? The recommendation to (page 59, paragraphs 3 and 4) "Periodically evaluate release success" should be presented more seriously. Release success should be under constant scrutiny and summarized on an annual basis. The results should be used to determine suitability of the release site, effectiveness of the release method, and whether the project in question should continue.

Response: Standards are desirable. Standards were used in selecting Florida as the area to endeavor to establish a nonmigratory population. Standards were also followed when the

cross-fostering project was evaluated and discontinued. Undoubtedly, standards will be identified before another reintroduction site is selected within the United States. Factors being used in the Canadian recovery effort to select a release site for a second migratory population include disturbance, access, ownership, local support for the reintroduction, resident sandhill crane populations and their migration pathway, and habitat features.

The rule published in the Federal Register describing the reintroduction in Florida mentions annual evaluation of the project. All ongoing projects are reviewed and evaluated annually and opportunities for changes exist at that time. Appropriate standards are difficult to identify for a k-selected species for which there is relatively little reintroduction experience and only small sample sizes. In the first release of Mississippi sandhill cranes the survival one year after release was zero percent. If the suggested standard noted above had been followed, then the Mississippi releases would have been terminated. Additional releases were made, and over the years the survival one year after release has increased to 80 to 100 percent. The wild population has been very ably supplemented and a majority of the birds now in the wild are from captive-production. Some of these birds are now successful breeders. If there is a biologically sound reason why survival does not meet a predetermined level, and there is a likelihood the problem can be corrected, an effort should be made to correct the problem before a project is prematurely ended because a standard is being rigidly followed.

The 10-member whooping crane recovery team is comprised of personnel with many years experience with cranes of North America in captivity and in the wild over broad geographic areas. Six members each have 25 or more years experience with cranes, one has 20 years, and one has 10 years. Most members have devoted a significant part of their career to benefit cranes. Information was solicitated from others who are not team members. The Service and the recovery team are concerned about efficient use of the crane resources and funding and can be counted on to recommend termination of a project whenever it is clear that it is biologically unsound. Standards should be general guidelines of purposes and goals, and team members should exercise their professional judgement in making recommendations to implement recovery.

Comment: The work with sandhill cranes at Seney represents the only successful, large-scale reintroduction of cranes into a migratory situation that has ever been accomplished.

Response: As noted previously, the work at Seney was a useful contribution to our knowledge about conditioning cranes for wild release in a migratory situation. However, the results should be kept in proper perspective. It was not a reintroduction in a depopulated area, but rather a release of captive-reared birds which resulted in supplementing a growing migratory population of the same species.